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Biological Criteria

Guide To Technical Literature

Biological Criteria: Guide To Technical Literature

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CONTENTS

INTRODUCTION

Biological surveys of populations and communities inhabiting waterbodies have long been used to assess the impact of contaminants on receiving waters. However, the development and widespread use of formal biological criteria (biocriteria) has lagged behind chemical-specific or toxicity-based water quality criteria (U.S. EPA 1985, 1986) in water quality management. Recent recommendations (U.S. EPA 1987), regarding water monitoring strategies point to the need to accelerate the development of ambient biological sampling in surface water programs.

Biocriteria are derived directly from ambient biological sampling programs. Briefly stated, biocriteria require direct measurements of the structure and function of resident aquatic communities to determine biological integrity and ecological function. When implemented, biological criteria will expand and improve water quality standards, help identify impairment of beneficial use, and help set program priorities. Biological criteria are valuable because they directly measure the condition of the resource at risk, detect problems that others may miss or understand, and provide a systematic process for measuring progress resulting from the implementation of water quality programs.

Based on State interest in having EPA guidance (U.S. EPA 1988), program and technical guidance documents for implementing biological criteria are being developed. The EPA Biological Criteria National Program Guidance Document for Surface Waters (U.S. EPA 1990) discusses program issues pertinent to biocriteria development including legislative authority, steps in developing biocriteria, and the application of biocriteria to surface water management. Interested readers are referred to the program guidance document for discussion of these issues.

In addition, EPA is in the process of developing technical guidance for streams and rivers, lakes and reservoirs, estuaries and near-coastal areas, and wetlands. The technical guidance for streams and small rivers is currently in draft form and guidance for the remaining habitat types is scheduled for publication over the next several years.

The present document is intended to serve as a general technical reference source for publications pertinent to the development of biological criteria. The references listed herein discuss methods and procedures appropriate to the development of biocriteria in streams and rivers, lakes and reservoirs, estuaries and near coastal areas, and wetlands. These references represent an initial compilation, and if it proves to be sufficiently useful, the reference catalog will be periodically updated.

Please direct comments or inquiries to Dr. George R. Gibson Jr., U.S. Environmental Protection Agency (WH-585), 401 M Street SW, Washington, D.C., 20460.

The Reference Catalog

The Reference Catalog presents methods and procedures relevant to bioassessment and the development of biocriteria. It is intended to summarize the references, and provide general information on manpower requirements to implement methods for developing biocriteria. The Section on "The Influence of Habitat on Biological Integrity" presents methods and procedures pertinent to habitat evaluation in bioassessment. The presentation consists of a list of references found in the Reference Catalog, followed by a general discussion for streams and rivers, lakes and reservoirs, estuaries and near-coastal areas, and wetlands. This general format is followed for the Sections on "Biosurvey Methods to Assess Biological Integrity," and "Data Analysis." The reference entries which make up the bulk of the Catalog are given in the back.

Each entry in the Reference Catalog is presented in a standard format (Figure 1). In addition to the basic reference, each entry provides information on the procedure objectives, suitability of the entry for the four major surface water types, advantages and disadvantages of the procedure, level of education needed to perform the procedure, field team size, collection time required, sample processing time, and data analysis time. Each entry is further categorized regarding its applicability for major subsections and community groups (see Figure 1).

Reference Number – 3

1. **Basic Reference:** Adamus, P. R., E. J. Clairain, Jr., R. D. Smith and R. E. Young. 1987. "Wetland Evaluation Technique: Vol. II - Methodology," AD-A189, Report to the Department of the Army and U.S. Department of Transportation, 206 pp.
2. **Procedure Objectives:** Outline of a wetland evaluation technique for the assessment of wetland functions and values.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Assists managers in techniques for wetland evaluation.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

x Macrophytes	Zooplankton	x Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 4

1. **Basic Reference:** Aggus, L. R., J. P. Clugston, A. Houser, R. M. Jenkins, L. E. Vogele and C. H. Walburg. 1980. "Monitoring of Fish in Reservoirs", in Biological Monitoring of Fish, C. H. Hocutt and J. R. Stauffer, Jr. Eds., D.C. Heath and Co., pp. 149-175.
2. **Procedure Objectives:** Review of fish-sampling gear and methods in terms of reservoir sampling (gillnets, trammul nets, fyke nets, trap nets, trawls, seines; rotenone, SCUBA, electrofishing).
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Various techniques discussed with respect to advantages and disadvantages in biomonitoring in reservoirs.
5. **Level of Education Needed to Perform Procedure:** Extensive knowledge of fish collection methods and identification. Also knowledge of sample design and analysis.
6. **Field Team Size:** Varies with method
7. **Collection Time Required:** Varies with method
8. **Sample Processing Time:** Varies with method
9. Data Analysis Time: Varies with method

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Figure 1.—Specimen of a reference citation in the reference catalog.

The references are arranged alphabetically and are sequentially numbered. Each reference number is unique and is used to cross-index the references by habitat type, the major subsection categories, and community group. To provide ease of use, the Reference Catalog is arranged as a series of appendices.

- **Appendix A** provides a list of reference numbers for freshwater environments. Entries are categorized under General Freshwater, Streams and Rivers, and Lakes and Reservoirs, as well as the major subsections and community groups shown in Figure 1.
- **Appendix B** provides a list of references numbers for estuarine and near-coastal environments categorized under the major subsections and community groups shown in Figure 1.
- **Appendix C** provides a list of reference numbers for wetland environments. Entries are categorized under the major subsections and community groups shown in Figure 1.
- **Appendix D** provides an alphabetical author/reference number cross-index.
- **Appendix E** consists of the actual catalog entries.

The Influence of Habitat on Biological Integrity

All surface water types exhibit functional similarities regarding ecological community function. However, the biological integrity of a given site is dependent upon its physical habitat and the organisms that live within the habitat. Therefore, different surface water types and different habitats within a specific surface water type may contain unique species assemblages. Furthermore, different surface water types may require different habitat assessment techniques tailored to the unique characteristics of the waterbody of interest. This section presents habitat measures that may be used in bioassessment involving streams and rivers, lakes and reservoirs, estuaries and near-coastal areas, and wetlands. A listing of references pertinent to habitat assessment methods and procedures are provided in Appendices A, B, and C for freshwater, estuarine and near-coastal, and wetland surface water types, respectively. For readers interested in work of specific authors, an alphabetical author/reference number cross index appears in Appendix D. Full references and highlights of the reference are presented in the Reference Catalog (Appendix E).

Habitat Assessment for Streams and Rivers

Habitat measures for streams and rivers have been extensively studied. A general overview of habitat assessment is presented in the Rapid Bioassessment Protocol Guidance Document (U.S. EPA 1989), and summarized below. Habitat assessment in streams and rivers can be based on evaluating primary, secondary, and tertiary habitat components.

- **Primary habitat parameters** have a direct influence on species composition and abundance. Primary parameters for streams and rivers include the following:
  - ✔**Bottom substrate** refers to the composition of the stream or river bottom ranging from rocks to mud. Bottom substrate can also refer to structures such as logs, tree roots, vegetation, and undercut banks. The amount and desirability of the bottom substrate will directly affect the type of aquatic life present.
  - ✔**Embeddedness** is the degree to which boulders, rubble, or gravel are surrounded by fine sediment. Embeddedness affects habitat which directly affects benthic macroinvertebrate distribution and abundance and fish spawning.
  - ✔**Stream or river flow** and/or **velocity** relates to the ability of the habitat to provide and maintain a stable environment. For practical purposes, flow should not be excessively slow or fast at the ideal collection site.
- **Secondary habitat parameters** refer to channel morphology and have less impact on aquatic life than the primary parameters. Secondary parameters for streams and rivers include the following:
  - ✔**Sediment deposits** from watershed and bank erosion indicate stream/river stability. Channelization straightens, and consequently increases stream and river velocity contributing to bottom scouring.
  - ✔**High velocity flows** contribute to scouring, which results in the movement of sediment into pools and riffles.
  - ✔**Pool-to-riffle** or **run-to-bend ratios** refer to habitat diversity, which increases aquatic life diversity. Use whichever parameter is dominant.

- **Tertiary habitat parameters** refer to riparian and bank structure and have less effect on aquatic life than primary or secondary parameters. Tertiary parameters for streams and rivers include:

  ✔**Bank stability** refers to the bank's ability to prevent soil loss into the stream or river. Steepness of the bank and soil type affect bank stability. Unstable banks cause increased sedimentation of systems.

  ✔**Bank vegetation** is the main factor affecting bank stability. Larger substrates, such as rocks or gravel, will also help maintain banks.

  ✔**Streamside cover** refers to vegetation that provides cover or shading and possible refuge for fish. Streamside cover also provides vegetative material that serves as nutrients for streams or rivers, and may maintain lower summer temperature through shading.

Habitat assessment references for streams and rivers (Appendix A) are listed in the Reference Catalog (Appendix E), and include references 17, 55, 65, 84, 102, 107, 110, 112, 117, 123, 131, 132, 136, 157, 173, 179, 180, 181, 189, and 207.

Habitat Assessment for Lakes and Reservoirs

Certain habitat measures for lakes and reservoirs are similar to those for streams and rivers, with some modification. Lotic (non-flowing) systems lack the flow of lentic (flowing) systems, and parameters such as flow and velocity, channel alteration, bottom scouring and deposition, and pool-to-riffle or run-to-bend ratios are deleted or replaced. Furthermore, primary, secondary, and tertiary habitat parameters have not been categorized with respect to their influence in the distribution and abundance of biota in lakes and reservoirs.

- **Habitat characteristics** for lakes and reservoirs that may be useful in bioassessment are discussed below:

  ✔**Bottom substrate** refers to the lake or reservoir bottom sediment ranging from rocks to mud. Bottom substrate can also refer to structures such as logs, tree roots, vegetation, and undercut banks. The amount and quality of bottom substrate will directly affect the type of aquatic life present.

  ✔**Embeddedness** is the degree to which boulders, rubble, or gravel are surrounded by fine sediment. Embeddedness affects benthic macroinvertebrates and fish spawning.

  ✔**Lake/reservoir inflow and outflow, currents, wave action, and flushing rate** refer to water movement. These parameters vary with the type and size of the waterbody system studied. All affect aquatic life to some degree.

  ✔**Lake and reservoir water level** has a direct impact on aquatic life. A system during a natural or artificial drawdown functions differently than a system during flood conditions.

  ✔**Sedimentation** refers to the rate at which sediment accumulates in lakes and reservoirs. Sedimentation will affect benthic macroinvertebrates directly by possible smothering, and fish indirectly by destruction of spawning areas.

  ✔**Morphology** refers to factors such as surface area, shoreline volume, mean depth, maximum depth, and bottom shape (bathymetry). The shape of the system helps to dictate the type of aquatic life supported.

  ✔**Stratification** refers to a vertical thermal gradient that develops during warmer periods and divides the system into two distinct layers. Stratification will affect both benthic macroinvertebrates and fish. For example, oxygen depletion in the colder, bottom layer may limit fish and some benthic macroinvertebrates.

  ✔**Bank stability** affects sedimentation soil loss into lakes and reservoirs. Steepness of bank and soil type will effect bank stability. Unstable banks cause increased sedimentation into systems.

  ✔**Bank vegetation** is the main factor affecting bank stability. Larger substrates such as rocks will also help maintain banks.

  ✔**Lakeside cover** refers to vegetation that provides cover of shading and possible refuge for fish. Lakeside cover provide allochthonous material for the system.

  ✔**Geomorphology** affects water quality and the biota. A lake is the product of its watershed, and is influenced by the size and overall characteristics of a drainage basin.

  ✔**Trophic status** refers to the productivity and food chains of a system. Trophic status may range from oligotrophic (low production) to

mesotrophic, (medium production) and eutrophic (high production).

✔**Water quality characteristics** include a number of variables such as temperature, dissolved oxygen, pH, conductivity, alkalinity, hardness, color, turbidity.

Habitat assessment references for lakes and reservoirs (Appendix A) are listed in the Reference Catalog (Appendix E), and include references 6, 50, 61, 125, 134, 163, 201, and 207.

Habitat Assessment for Estuaries and Near-Coastal Areas

Estuaries and surrounding near-coastal areas are transition zones from fresh to salt water that form complex, highly-variable habitats. Because estuarine classification is a necessary aspect of estuarine and near-coastal habitat assessment, several classification systems precede a discussion of habitat measurement methods. To date, habitat measures in estuaries have not been categorized into the primary, secondary, and tertiary parameter categories described for freshwater streams and rivers.

Habitat within an estuary is a function of physical factors that influence water circulation and allied conditions such as salinity, dissolved oxygen, and turbidity. When conducting bioassessment studies in estuaries and near-coastal areas, the system under study must be carefully classified to determine which habitat measures are most important. Generally, geomorphology, tides, and freshwater inflow are the major factors influencing circulation and salinity. Other factors include topographic frictional resistance, the Coriolis effect (an effect of the earth's rotation), and vertical and horizontal mixing. Estuarine classification systems are fully described elsewhere (Ketchum, 1983 and U.S. EPA, 1984) and are only briefly summarized here.

Estuaries and near-coastal areas are generally classified according to geomorphology, salinity and density stratification, and the characteristic type of circulation. Such classifications are interdependent because geomorphology, combined with tidal ranges and river flows, affects salinity distribution and determines dominant circulation mechanisms.

■ **Geomorphological estuarine categories** are described below:

✔**Coastal plain estuaries** are shallow with gently sloping bottoms and uniformly increasing depth towards the mouth. Such estuaries are drowned river valleys cut by erosion, and often display a dendritic pattern fed by several streams (e.g., Chesapeake Bay). Coastal plain estuaries are usually moderately stratified and can be highly influenced by wind.

✔**Fjords** are characterized by deep water, steep sides, and are generally long and narrow. Fjords are typical of Alaska rather than the contiguous United States. Little sediment deposition occurs in fjords that receive freshwater from streams passing through rocky terrain. Fjords are usually highly stratified, with deeper waters cooler and more saline than the surface layer.

✔**Bar-built estuaries** are enclosed by a sand bar with a channel that exchanges water with the open sea. Bar-built estuaries typically service rivers with relatively small discharges. These estuaries are unstable and subject to gradual seasonal and catastrophic variations in configuration (e.g., Gulf coast estuaries). They are generally a few meters deep, well mixed, and highly influenced by wind.

✔**Other estuaries** (not described above) are usually produced by tectonic activity, faulting, landslides, or volcanic eruptions (e.g., San Francisco Bay, formed by movement of the San Andreas Fault). Due to the great variability within this category, few generalizations can be made.

■ **Estuarine categories** derived from salinity and density-induced stratification include *highly stratified, partially mixed,* and *vertically homogeneous* estuaries. The salinity stratification classifications generally reflect stream discharge.

✔**Highly stratified estuaries** are characterized by large freshwater inflows riding over saline waters, with little mixing between layers. Averaged over a tidal cycle, such estuaries exhibit net seaward movement in the freshwater layer, and net landward movement in the salt water layer (e.g., Mississippi River).

✔**Partially mixed estuaries** are systems where the density differences between fresh- and salt water layers are partially disrupted at the interface of the layers. Tidal flows are generally greater than river flows. Flow reversals in the lower layers may be observed, but are usually smaller than those of highly stratified systems. Examples include Chesapeake Bay and James Bay.

✔**Vertically homogenous estuaries** generally have a small river inflow. Such systems are usually shallow with a large amplitude to depth ratio so tidal flow easily penetrates the water column, resulting in a thoroughly mixed vertical system (e.g., Delaware and Raritan River estuaries).

Estuarine classification categories based on circulation have not been established. However, circulation is important in determining the physical and biotic processes of estuaries. Circulation is affected by freshwater outflow, tidal flow, and wind. In turn, the density difference between inflow and outflow establishes secondary currents that affect the salinity distribution across the entire estuary. Salinity is an important determinant for the distribution of fauna and flora. Frictional forces, size, and geometry of an estuary also contribute to circulation patterns. Estuarine geometry, wind, and the effect of the earth's rotation (Coriolis effect) result in residual currents (longer period than the tidal cycle) that influence estuarine mixing. Detailed discussions of estuarine circulation are given in Ketchum (1983) and U.S. EPA (1984).

Freshwater inflow is another characteristic that influences estuarine habitat. Primary sources of freshwater inflow for estuaries include direct precipitation and streamflow. Streamflow contributes more freshwater than precipitation and has the greatest effect on estuarine salinity gradients. Because salinity influences the distribution of estuarine biota, salinity gradients are important in determining the comparability of estuarine and near-coastal reference and study sites. Salinity gradients are affected by low and high streamflows. The resultant variability may induce population shifts as species adjust to salinity changes. Salinity variations generally follow seasonal patterns, with the salt front occurring further down-estuary during periods of high freshwater inflow. Salinity profiles may also undergo major changes caused by meteorological events such as hurricanes or severe drought.

Because estuaries are complex systems with varied habitat, dividing an estuary into segments provides a framework for evaluating the influence of circulation, mixing, salinity, and geomorphology on reference sites and study sites. Segmentation allows compartmentalization of an estuary into comparable subunits with homogeneous physical characteristics. Accordingly, differences in biological communities can be compared among similar segments. These segments may be delineated based on physical factors such as salinity and circulation patterns. The segmentation approach has been used in large estuary studies such as the U.S. EPA Chesapeake Bay Program (U.S. EPA 1984).

Another method to evaluate estuarine physical processes involves calculating indicator parameters including: degree of stratification, flushing time, and various pollutant concentrations. Formulae for such calculations are located in U.S. EPA (1984).

Habitat classification systems and measures for estuaries and near-coastal areas (Appendix B) listed in the Reference Catalog (Appendix E) include references 10, 36, 96, 136, 147, and 170.

Habitat Assessment for Wetlands

Like estuaries, wetland environments are complex and require some consideration of classification schemes and habitat measures. Wetland habitats are defined by plants, soils (hydric soils), and frequency of flooding. The Canadian government has developed a classification system based on species composition, stability, and gross appearance (Millar, 1976). In the United States, the wetland classification system most frequently used was developed by the U.S. Fish and Wildlife Service (Cowardin et al. 1979). This classification system is hierarchical, and includes wetlands and deepwater habitats, categorized into systems, subsystems, classes (based on substrate material and flooding regimen, or on vegetative life form), subclasses, and dominance type (named for the dominant plant or animal forms). The hierarchical system allows flexibility in the level of wetland discrimination based on the needs of the investigation. Each hierarchial level is discussed below.

- **Systems** include Marine, Estuarine, Riverine, Lacustrine, and Palustrine classifications. The first four systems include deepwater habitats (2 meters deep) as well as wetlands. Palustrine systems include only non-tidal, low-salinity wetlands dominated by emergent trees or shrubs.
- **Subsystems** are delineated for four of the major systems. Marine and Estuarine systems each have Subtidal and Intertidal subsystems. The Riverine system has Tidal, Lower Perennial, Upper Perennial, and Intermittent subsystems. The Lacustrine system has Littoral and Limnetic subsystems. The Palustrine system has no subsystems, but like the others, is divided into various classes.

- **Classes** describe the general appearance of the habitat by dominant vegetation if 30% of the substrate is vegetation-covered, or by physiography and substrate composition if 30 percent of the substrate is vegetation-covered. Vegetative classes are further characterized by life forms (trees, shrubs, emergents, emergent mosses, lichens, aquatic beds).
- **Subclasses** are based on finer distinctions of vegetation type (i.e. Forested Wetlands are further classified as Broad-leaved Evergreen or Dead).
- **Dominance** types are based on the dominant plant species.

The most abundant wetland habitat types identified under this system are Estuarine Emergent Wetlands, Estuarine Intertidal Flats, Estuarine Scrub-Shrub Wetlands, Palustrine Emergent Wetlands, Palustrine Scrub-Shrub Wetlands, and Palustrine Forested Wetlands (Tiner 1984).

Several recent studies have addressed the issue of cumulative impacts on wetlands using landscape perspectives. Klopatek (1988) presented a landscape-oriented classification scheme that uses environmental constructs of the wetland to obtain information on life-support functions. The landscape approach separates wetlands into hierarchical ecological regions and landscape elements. This classification also allows for predetermination of environmental constraints and the possible natural limits of wetland food chain support. Preston and Bedford (1988) presented a generic framework for evaluating cumulative effects on three basic wetland landscape functions: flood storage, water quality, and life support. Issues that need to be defined for this framework include delineation of scales, identification of threshold responses, and the influence on wetland functions of wetland size, shape, and position in the landscape.

Adams et al. (1987) developed a "Wetland Evaluation Technique" (WET) for the assessment of wetland functions and values. WET includes an assessment of social "value" of wetlands in addition to functional components. Functions and values include groundwater recharge, groundwater discharge, flood flow alteration, sediment stabilization, sediment/toxicant retention, nutrient removal and transformation, product export, wildlife diversity and abundance, aquatic diversity and abundance, uniqueness and heritage, and recreation. The functions and values are evaluated using predictors, which are simple or integrated variables correlated with the physical, chemical, and biological characteristics of the wetland and its surroundings. WET also assesses the suitability of wetland habitat for 14 waterfowl species groups, 4 freshwater fish species groups, 120 species of wetland-dependent birds, 133 species of saltwater fish and invertebrates and 90 species of freshwater fish.

Habitat classification and assessment references for wetlands (Appendix C) in the Reference Catalog (Appendix E) include references 1, 2, 3, 18, 19, 21, 22, 42, 43, 56, 58, 104, 120, 124, 126, 129, 136, 140, 168, and 202.

Biosurvey Methods to Assess Biological Integrity

A listing of references pertinent to biotic measures are provided in Appendices A, B, and C for freshwater, estuarine and near-coastal, and wetland surface water types respectively. For readers interested in work by specific authors, an alphabetical author/reference number cross index appears in Appendix D. Full references and highlights of the references are presented in the annotated Reference Catalog (Appendix E).

Ecological systems are composed of populations and communities. However, species assemblages, dominant taxa, and ecologically and economically important species may vary by region, by locality, by surface water type, and by habitat. Therefore, methods for the collection of data about various assemblages, taxa, and species must be carefully selected to ensure compatibility with the study objective, surface water type, and habitat. As an example, fish community structure may be a useful biological criterion in streams, rivers, lakes, reservoirs, estuaries, and near-coastal waters. However, different collection methods are necessary to adequately sample different species assemblages. Furthermore, evaluating the fish communities in different surface water types will require specific knowledge about different communities in these waters to allow informed judgments of their biological integrity.

Biotic Assessment in Freshwater

Previous sections of this report categorized freshwater references into streams and rivers, and lakes and reservoirs. Such categories are useful because different habitat types require a different selection of collection methods for biosurveys. However, there is a great deal of overlap in freshwater organism collection methods. Accordingly, these collection pro-

cedures are arranged by major taxonomic grouping rather than by habitat type.

Biotic assessment references for freshwater (Appendix A) are listed in the Reference Catalog (Appendix E). Reference numbers for citations pertinent to general freshwater, streams and rivers, and lakes and reservoirs include:

General Freshwater	5, 7, 11, 18, 19, 20, 24, 25, 26, 27, 28, 29, 30, 31, 38, 39, 44, 45, 46, 48, 49, 52, 55, 58, 59, 63, 66, 69, 70, 72, 73, 74, 76, 77, 78, 80, 81, 85, 86, 87, 89, 93, 94, 97, 101, 103, 09, 112, 113, 114, 115, 116, 117, 119, 121, 122, 123, 128, 130, 131, 132, 135, 136, 141, 144, 145, 146, 152, 153, 154, 158, 159, 164, 165, 169, 173, 174, 175, 179, 180, 181, 185, 186, 187, 188, 194, 195, 197, 199, 200, 203, 205, 206, 209
Streams and River Freshwater	8, 9, 12, 15, 16, 17, 35, 37, 41, 51, 54, 64, 65, 71, 74, 75, 82, 83, 84, 88, 90, 91, 92, 99, 102, 106, 107, 108, 110, 111, 134, 137, 138, 139, 142, 143, 148, 149, 156, 157, 162, 166, 167, 189, 190, 196, 198
Lakes and Reservoirs Freshwater	4, 6, 23, 33, 34, 40, 50, 53, 60, 61, 62, 68, 95, 100, 104, 118, 125, 134, 150, 151, 160, 161, 163, 191, 193, 201, 204, 207

A variety of fish collection methods and gears are available, but each has selection biases (size class or species) that require consideration prior to use. General discussions regarding the selection of fish capture techniques are found in Hocutt and Stauffer (1980) and Nielsen and Johnson (1983). Reference numbers for fish references listed in this catalog include 4, 8, 9, 11, 16, 18, 19, 46, 48, 51, 54, 55, 60, 62, 65, 66, 69, 71, 72, 78, 81, 86, 89, 90, 91, 92, 93, 101, 102, 103, 108, 110, 113, 114, 123, 125, 130, 146, 155, 161, 162, 163, 170, 173, 179, 180, 181, 185, 194, and 203. The following discussion is a summary of techniques listed in the Reference Catalog (Appendix E).

- **Gillnets and trammel nets** are size and species selective and should only be used to collect target species. Such nets were designed for lentic environments, but modified techniques can make them useful in lotic systems. These nets can be used for age and growth and condition-factor analysis, as well as food habit analysis. A disadvantage of these nets is that fish are usually killed.

- **Trap nets, hoop nets and fyke nets** are also size and species selective, but have an advantage over gill nets because fish can usually be released alive. Trapping devices can collect data similar to that from gill and trammel nets except that fish may feed in the net, excluding their use in food habit analysis.

- **Seines** are less biased than the previous capture devices, but are restricted to shallow areas with unobstructed bottoms in lotic habitats. Seines can be used in various ways and are usually fished until further sampling will not yield new species. Knowledge of fish habitats is an important factor in the use of seines.

- **Purse seines** have been used in lakes and reservoirs to collect fish associated with the surface. Purse seines are rarely used in freshwater, but have provided useful information for some habitats.

- **Trawls** are best used in larger systems with limited bottom obstructions. Midwater trawls are also good devices for collecting pelagic fish, and are non-selective, especially when used at night to eliminate fish avoidance. Trawls are labor- and capital-intensive and fish are sometimes killed by smothering. However, trawls may be the only feasible fish collecting technique for certain habitats.

- **Ichthyocides** are selective poisons that provide standardized and non-selective data but are time- and seasonal-intensive. Rotenone is a commonly used fish poison. Following application, dead or dying fish are collected by dipnets or blocknets. Appropriate rotenone application and subsequent oxidation with potassion permanganate is critical so that fish kills are restricted to the sampling location.

- **Electrofishing** is perhaps the best-suited general method for control collection of fish. Electrofishing gear is less selective than netting devices, more cost-effective than ichthyocides, and produces semi-quantitative data. The specific type of electrofishing equipment and technique depends on the size of the system being sampled. Back-pack shockers are relatively effective for smaller systems, while boat-mounted shocking units work better in large systems. Safety precautions should be strictly enforced while using electroshocking devices.

- **Other methods** are available, including scuba, underwater television, sport and commercial catch records, and biotelemetry.

Macroinvertebrates are perhaps the most commonly used group of aquatic organisms to assess impacts on freshwater habitats. The following discussion is a summary of macroinvertebrate references listed in the Reference Catalog (Appendix E). Reference numbers for citations listed include 7, 11, 12, 15, 16, 17, 18, 19, 29, 35, 37, 39, 41, 44, 49, 52, 53, 63, 64, 70, 72, 73, 74, 75, 76, 77, 83, 85, 86, 87, 95, 97, 99, 100, 104, 106, 107, 112, 115, 125, 128, 131, 137, 138, 139, 142, 143, 144, 145, 148, 151, 152, 153, 155, 156, 157, 159, 163, 166, 167, 169, 170, 171, 173, 179, 180, 181, 185, 186, 189, 191, 194, 195, 198, 203, 204, and 205.

The basic methods used for macroinvertebrate collection are dependent upon the habitat type and objectives of the study. Ekman and ponar dredges are well suited for use in soft freshwater sediments. Both devices grab bottom sediment, but the ponar is heavier and better suited for firmer substrate or large lakes of greater depth. The two dredges provide quantitative data that can be statistically analyzed. Using dredges in weedy or debris-filled areas, as well as shoreline areas can be problematic.

Artificial substrates are amenable for use in lotic as well as lentic systems. In practice, artificial substrates introduce a uniform substrate for colonization by invertebrates for a period of one to four weeks. When used, they should be carefully equated to existing habitat conditions so data collected is not misinterpreted. Two types of artificial substrates have been extensively used. The multi-plate and rock-basket artificial substrates have advantages and disadvantages. The main advantage of artificial substrates is that sampling is quantitative and can be statistically analyzed. A disadvantage of artificial substrates is that the colonization period increases field time because placement and retrieval are required. Artificial substrates are also prone to loss through vandalism.

Kick-nets have been used with success to collect qualitative data quickly and easily. Kick-net samples can be obtained from a variety of habitats in near shore area. However, kick-net samples are restricted to shore areas and may be difficult to quantify statistically. The travelling kick-net method is one means of quantifying samples by the amount of time spent sampling over the approximate surface area sampled. A Surber square-foot sampler can also be used to provide reproducible samples. Kick-net and Surber type samples are effective in straight stream riffles and other shallow habitats, but do not allow quantitative estimates of densities or biomass of macroinvertebrates per unit area. Nevertheless, such sampling devices are suitable for determining taxa richness, presence of indicator organisms, relative abundance, and similarity between sites.

Biotic Assessment in Estuaries and Near-Coastal Areas

Reference numbers for citations pertinent to estuaries and near-coastal areas include references 10, 13, 14, 18, 19, 24, 25, 26, 28, 30, 31, 36, 38, 47, 48, 57, 58, 66, 67, 69, 73, 78, 79, 81, 85, 86, 89, 96, 116, 119, 121, 122, 127, 130, 133, 135, 136, 145, 146, 155, 158, 164, 170, 171, 172, 174, 182, 192, 206, 208, 209, and 210.

Estuarine biota are typically characterized by low diversity and high productivity. The low species diversity is attributable to widely fluctuating environmental conditions, such as seasonal salinity changes and desiccation during low tides. High productivity is generally attributed to the increased availability of nutrients. Fish and benthos are the groups usually measured. However, other groups such as phytoplankton, zooplankton and submerged aquatic vegetation may also be assessed.

References pertinent to fish collection in estuarine and near-coastal areas include 10, 18, 19, 48, 66, 69, 78, 81, 86, 89, 96, 127, 130, 152, 155, 170, 182, 192, and 206. Eight major methods are available for collection of fish data (Richkus, 1980). These include bottom trawls, midwater trawls, hauls (beach seine), purse seines, drop nets, sonar, gill nets, and trap nets. Bottom trawls, seines, and gill nets are the most commonly used. Sonar is one of the newest methods, and purse seines and drop nets are the least used. Richkus (1980) compared the aforenamed methods by sample type (active or passive), the water column segment or target species sampled, the catch units, and the major factors influencing catch. The strengths and weaknesses of a specific method must be matched to the specific objectives of the study. For example, the catch efficiency of the method will be important in studies that estimate the absolute abundance.

Benthic macroinvertebrates are an important estuarine group that can be used to evaluate biological integrity. Citations pertinent to macroinvertebrates in estuarine and near-coastal areas include references 10, 18, 19, 47, 57, 67, 72, 73, 79, 85, 86, 96, 133, 145, 152, 155, 170, 171, 182, 192, and 208.

Estuarine sampling methods for macroinvertebrates are generally similar to those described for freshwater, including nets, dredges, and artificial substrates. The method selected should be appropriate to specific conditions of the estuary or portion of the estuary being sampled. Methods for

sampling estuarine and marine benthos are described in several general references mentioned above (Baker and Wolff 1987; and U.S. EPA 1983, 1989) and in Holme and McIntyre (1984).

In lieu of sampling the entire benthic community, indicator species have been used for long-term monitoring. DeGoursey et al. (1984) described a field technique for *in situ* monitoring of the mussel *Mytilus edulis* in which mussels were placed in net bags and attached to sampling platforms that could be easily located for repeated sampling over time.

References pertinent to zooplankton (10, 13, 14, 18, 19, 92, 182, 192), phytoplankton (10, 18, 19, 96, 182, 192), periphyton (10, 18, 19), and macrophyton (10, 18, 19, 86) for estuaries and near-coastal areas (Appendix B) are listed in the Reference Catalog (Appendix E).

Baker and Wolff (1987) describe methods for sampling estuarine flora and fauna. U.S. EPA (1989) provides methods for sampling water, sediment, biota, and air. References for methods specific to particular geographic regions have been developed, such as the Puget Sound Estuary Program protocols (U.S. EPA 1986-90).

Habitat requirements of target species can also be used to evaluate the biological integrity of an ecosystem. The Chesapeake Bay Program (Chesapeake Executive Council 1988) recently completed a study to determine the habitat requirements of living resources in the bay. Selected components of the Chesapeake Bay ecosystem (plankton, vegetation, benthos, and fish), habitat zonation by depth and salinity, and representative species of the various zones are described. Target species were selected from lists of representative species based on commercial, recreational, aesthetic, or ecological significance. The threat of population decline or serious habitat degradation to sustained production was also considered for target species selection. Critical life stages and critical life periods were next determined for these species, and a matrix of habitat requirements developed for each.

Biotic Assessment in Wetlands

Very few methods have been designed specifically to measure biota of wetlands. Biotic assessment references for wetlands (Appendix C) are listed in the Reference Catalog (Appendix E) for fish (1, 2, 3, 18, 19, 46, 86, 89, 103, 164, 168, 206), macroinvertebrates (18, 19, 86, 145, 152, 168, 209), macrophytes (18, 19, 42, 43, 56, 86, 120), and other vertebrates (1, 2, 3, 18, 19, 22, 168, 202).

Many of the methods previously discussed for freshwater and estuarine systems are applicable to wetlands. However, the characteristics of a particular wetland should be considered before such methods are applied. For example, wetlands that are seasonally dry would not be expected to support diverse fish populations, but these areas may be utilized by fish during the wet season for feeding and reproduction.

In addition to methods using aquatic life as monitors for wetland quality, vertebrates, primarily birds, have also been useful to assess wetland conditions. Cable et al. (1989) developed a wetland technique using birds as indicators of habitat quality. The index is calculated by dividing measures of species diversity and uniqueness (rare vs. common), by a factor that accounts for wetland size. Weller (1988) presented an approach for evaluating change in wetlands by assessing loss of waterbird habitat.

Data Analysis

Bioassessment study design has a straightforward objective: to determine whether anthropogenic impacts cause change in surface water ecosystems, and if so, to describe the nature of that change. Accordingly, study design and data analysis are an integral aspect of bioassessment.

Listings of references pertinent to data analysis are provided in Appendices A, B, and C, respectively for freshwater, estuarine and near-coastal, and wetland surface water types. For readers interested in the work of specific authors, an alphabetical author/reference number cross-index appears in Appendix D. Full references and highlights of the references are presented in the Reference Catalog (Appendix E).

Because few data analysis techniques are specific to surface water type or taxonomic groupings, procedures are discussed by major categories. Specific data analysis reference numbers for freshwater, estuarine and near-coastal, and wetlands cited in the Reference Catalog (Appendix E) are listed below.

Freshwater	8, 9, 11, 15, 17, 18, 19, 20, 27, 29, 31, 35, 38, 40, 48, 49, 50, 51, 53, 54, 58, 61, 63, 64, 70, 72, 74, 75, 78, 80, 85, 86, 88, 89, 90, 91, 92, 93, 97, 99, 101, 106, 111, 112, 113, 116, 121, 122, 123, 130, 131, 138, 139, 145, 156, 157, 158, 162, 163, 165, 171, 173, 179, 180, 181, 185, 187, 189, 190, 191, 193, 194, 195, 198, 203, 204, 205, 206, 207

Estuarine and Near-Coastal	10, 18, 19, 38, 31, 48, 58, 67, 78, 85, 86, 89, 116, 121, 122, 130, 145, 155, 170, 171, 192, 206, 208
Wetlands	18, 19, 31, 38, 58, 86, 89, 116, 121, 122, 145, 158, 206

Sampling Strategy and Statistical Approaches

In any impact study, choices must be made about how many samples, locations, variables, areas, and collection times should be used. Green (1978) provided an optimal sampling and analysis design which represents a theoretical ideal. The optimal design warrants attention, but recognizes that practical considerations generally dictate suboptimal designs.

Generally, the total number of samples collected in a bioassessment study will be determined by the number of locations and the number of areas under consideration, and at least three replicates per location should be considered. The number of variables should be consistent with an adequate description of the potential impact effects and natural background variation. Regarding the number of sampling areas, Green (1978) suggested a single control area and a single impact area has a logical neatness, but the use of several areas representing different degrees of impairment is advantageous. The optimal sampling times are immediately before an impact, with the after-impairment time chosen with regard to the type of impact involved and the response pattern of the biological community. Statistically, the optimal number of locations depends on distribution among locations and variability within locations. The interested reader is referred to references on sampling design (Cochran 1963; Saila et al. 1976; Sheldon 1984; Millard and Lettenmaier 1986; U.S. EPA 1973, 1989) for greater detail.

A number of statistical approaches are available for the analysis of bioassessment data. Bivariate and multivariate analyses may be applied to impact data and include analysis of variance (ANOVA), analysis of covariance (ANCOVA), correlation, and regression. Rigorous parametric statistical analysis requires validation of assumptions for the statistical distribution of the data. Nonparametric statistical analyses may be performed and are not reliant on data distribution assumptions. These tests include the chi-square test, binomial test, rank correlations, and nonparametric t-tests such as the Mann-Whitney U-test. The reader is referred to standard statistical references to obtain more detail of the statistical analyses of data.

Diversity Indices

Several diversity indices have been developed that combine the number of species and the number of individuals in a numerical grouping which can be used to compare a reference and a study site. In concept, the integrity of a community increases with the numerical value of the diversity index. However, low diversity may be caused by natural perturbations such as floods, drought, seasonality, or habitat modifications. Diversity indices, such as the Shannon-Weaver index (Shannon and Weaver 1949) or Brillouin's index (Brillouin 1962), remain in widespread use, yet various authors have questioned the reliability of diversity indices to detect certain perturbations (Hilsenhoff 1977, Hughes 1978, Washington 1984, Resh 1988). The history and use of diversity indices is reviewed by Washington (1984).

Biological Indices

Biotic indices use pollution tolerance scores for individual animal taxa and are weighted by the number of individuals assigned to each tolerance value. The first widely used biotic index was that of Beck (1955). More recently, Hilsenhoff's (1977, 1982) biotic index has gained widespread acceptance. Tolerance values for macroinvertebrates have been published by Hilsenhoff (1987). Biotic community indices are generally limited to streams and rivers impacted by organic enrichment or other perturbations (Hilsenhoff 1977, Murphy 1978, Hawkes 1979, Depauw et al 1986).

Similarity indices measure the similarity between benthic communities at a reference and a study site. High similarity indicates little difference between sites. Such indices have been reviewed elsewhere (Brock 1977, Washington 1984). Examples of similarity indices include those of Jaccard (1908), Van Horn (1950), Bray and Curtis (1957), and Brock (1977).

Because less work has been done in lentic systems, similar techniques for lakes and reservoirs are less developed. Techniques that have been used in lentic systems include oligochaete populations, oligochaete to chronomidae ratios, and other mathematical indices (U.S. EPA 1984).

Composite Community Indices

Composite community indices combine selected structural or functional measures, or "metrics," in a cumulative scoring index. Such indices have been

developed for several community and surface water types, and cover species richness and composition, functional feeding groups, and density.

Composite community indices (metrics) have been developed for fish (Karr 1981, Karr et al 1986, Ohio EPA 1987, Plafkin et al 1989) and macroinvertebrates (Plafkin et al 1989). The individual community indices for fish communities represent species abundance and composition (Figure 2, metrics 1 through 6), trophic composition (Figure 2, metrics 7 through 10), and fish abundance and condition (Figure 2, metrics 10 through 12). The individual metrics are scored using a value of 1, 3, or 5 depending upon the derived value of the metric (Figure 2). The individual score are then added to yield a total score which provides a numerical measure of the index of biological integrity (IBI) for the collection (Figure 3). The IBI score can range from excellent to very poor, and provides a measure for comparison to a reference site or condition.

Originally developed for midwestern U.S. streams, composite community index metrics have not yet been developed for lakes and reservoirs. The IBI has been modified for estuaries in Louisiana. The Index of Biotic Integrity concept has been used in Louisiana estuaries, but is considered a prototype (Miller 1988). The estuarine metrics include:

Species Richness and Composition

Metric 1. Total number of fish species

Metric 2. Number and identity of resident estuarine species

Metric 3. Number and identity of marine species

Metric 4. Number and identity of sciaenids

Metric 5. Number and identity of freshwater species

Metric 6. Proportion of individuals as bay anchovy

Metric 7. Measure of seasonal overlap of fish community

Metric 8. Number of species necessary to make up 90% of collection

Trophic Composition

Metric 9. Proportion of individuals as generalized benthic feeders

Metric 10. Proportion of individuals as generalized planktonic grazers

Metric 11. Proportion of individuals as top carnivores

Metric Scores (IBI)

Metric	Scoring Criteria[a] 5	3	1
1. Number of native fish species	>67%	33 - 67%	<33%
2. Number of darter or benthic species	>67%	33 - 67%	<33%
3. Number of sunfish or pool species	>67%	33 - 67%	<33%
4. Number of sucker or long-lived species	>67%	33 - 67%	<33%
5. Number of intolerant species	>67%	33 - 67%	<33%
6. Proportion of green sunfish or tolerant individuals	<10%	10 - 25%	>25%
7. Proportion ommnivorous individuals	<20%	20 - 45%	>45%
8. Proportion insectivores	>45%	20 - 45%	<20%
9. Proportion top carnivores	> 5%	1 - 5%	< 1%
10. Total number of individuals	>67%	33 - 67%	<33%
11. Proportion hybrids or exotics	0%	0 - 1%	> 1%
12. Proportion with disease/anomalies	< 1%	1 - 5%	> 5%

(a) Metrics 1-5 are scored relative to the maximum species richness line. Metric 10 is drawn from reference data.

Figure 2.—Individual fish community metric scoring criteria.

Index Score Interpretation[a]

IBI	Integrity Class	Characteristics
58 - 60	Excellent	Comparable to pristine conditions, exceptional assemblage of species
48 - 52	Good	Decreased species richness, intolerant species in particular; sensitive species present
40 - 44	Poor	Top carnivores and many expected species absent or rare; omnivores and tolerant species dominant
12 - 22	Very Poor	Few species and individuals present; tolerant species dominant; diseased fish frequent

(a) From Karr et al. 1986; Ohio EPA 1987.

Figure 3.—Fish community index score interpretation for determining the index of biological integrity (IBI) and integrity class.

Fish Abundance and Condition

Metric 12. Proportion of young of year in sample or number of individuals in sample

Metric 13. Proportion of individuals with disease, tumors, fin damage, and other anomalies

The IBI concept was originally developed for fish communities, but has been adopted and modified for use with macroinvertebrate communities (U.S. EPA 1989). The macroinvertebrate community indices for Rapid Bioassessment Protocol III included eight individual metrics (Figure 4) which are described below.

Metric 1. Taxa Richness—looks at the variety of taxa (families) present.

Metric 2. Modified Family Biotic Index—Use of tolerance limits of family-level organisms.

Metric 3. Ratio of Scraper and Filtering Collector Functional Feeding Groups. This metric reflects the riffle/run community foodbase.

Metric 4. Ratio of EPT and Chironomidae Abundance—Uses a measure of Ephemeroptera, Plecoptera, Trichopters, and Chironomidae to detect community balance.

Metric 5. Percent Contribution of Dominant Family. Uses abundance of dominant taxa relative to the rest of the population to determine community balance at the family level.

Metric	Biological Condition Scoring Criteria			
	6	4	2	0
1. Taxa Richness[a]	>80%	60 - 80%	40 - 60%	<40%
2. Hilsenhoff Biotic Index (modified)[b]	>85%	70 - 85%	50 - 70%	<50%
3. Ratio of Scrapers/Filt. Collectors[a,c]	>50%	35 - 50%	20 - 35%	<20%
4. Ratio of EPT and Chironomid Abundances[a]	>75%	50 - 75%	25 - 50%	<25%
5. % Contribution of Dominant Taxon[d]	<20%	20 - 30%	30 - 40%	>40%
6. EPT Index[a]	>90%	80 - 90%	70 - 80%	<70%
7. Community Loss Index[e]	<0.5	0.5 - 1.5	1.5 - 4.0	>4.0
8. Ratio of Shredders/Total[a,c]	>50%	35 - 50%	20 - 35%	<20%

(a) Score is a ratio of study site to reference site X 100.
(b) Score is a ratio of reference site to study site X 100.
(c) Determination of Functional Feeding Group is independent of taxonomic grouping.
(d) Scoring criteria evaluate actual percent contribution, not percent comparability to the reference station.
(e) Range of values obtained. A comparison to the reference station is incorporated in the indices.

Figure 4.—Individual macroinvertebrate community scoring criteria.

Metric 6. EPT Index—Measures abundance of pollution intolerant organisms (Ephemeroptera, Plecoptera, Trichoptera).

Metric 7. Community Similarity Indices—Use of a reference community to compare to the test site. Three of the main indices used are : (1) Community loss index; (2) Jaccard coefficient of community similarity; and (3) Pinkham and Pearson Community Similarity Index.

Metric 8. Ratio of Shredder Functional Feeding Group and Total Number of Individuals Evaluates the shredder group in comparison with the other functional groups to determine possible loss of the detritus-based shredder community.

As with the fish community (Figures 2 and 3), the individual macroinvertebrate metrics are scored and totaled, but the process is somewhat different for the two community segments. Each macroinvertebrate metric is given a score of 0, 2, 4, or 6 based on percent comparability to a reference station (Figure 4). Scores are then totaled and a Biological Condition category is assigned based on percent comparability and the reference station score (Figure 5). The obtained values may be intermediate to established ranges, and will then require best professional judgement as to the biological condition.

The growing acceptance and flexibility of composite community index metrics make them desireable for the development of biological criteria. However, other approaches have also been employed and are equally acceptable.

Community based methods and procedures such as IBI, the Rapid Bioassessment Protocols, and ecoregional reference conditions focus attention on practical, yet scientifically defensible information in biocriteria development and bioassessment. The composite community index approach reflects the inherent ecological information in biosurvey data, and this approach will likely see increased development for different surface water types and habitats.

Bioassessment

% Comp. to Ref. Score[a]	Biological Condition Category	Attributes
>83%	Nonimpaired	Comparable to the best situation to be expected within an ecoregion. Balanced trophic structure. Optimum community structure (composition and dominance) for stream size and habitat quality.
54 - 79%	Slightly Impaired	Community structure less than expected. Composition (species richness) lower than expected due to loss of some intolerant forms. Percent contribution of tolerant forms increase.
<21 - 50%	Moderately Impaired	Fewer species due to loss of most intolerant forms. Reduction in EPT index.
<17%	Severely Impaired	Few species present. If high densities of organisms, then dominated by one or two taxa.

(a) Percentage values obtained that are intermediate to the above ranges will require subjective judgement as to the correct placement. Use of the habitat assessment and physiochemical data may be necessary to aid in the decision process.

Figure 5.—Macroinvertebrate community biological condition category for determining impairment.

APPENDIX A

Freshwater Environments

Listing of references in the Reference Catalog for freshwater environments.

Catalog entries are sorted by the following major headings:

Habitat Assessment

Population Structure

Community Structure

Population and Community Interactions

Data Analysis

Interpretive Assessment

Listings under each of the major headings shown above are further sorted under the following subheadings:

Macrophytes

Periphyton

Phytoplankton

Zooplankton

Macroinvertebrates

Fish

Other

General Freshwater	5, 7, 11, 18, 19, 20, 24, 25, 26, 27, 28, 29, 30, 31, 38, 39, 44, 45, 46, 48, 49, 52, 55, 58, 59, 63, 66, 69, 70, 72, 73, 74, 76, 77, 78, 80, 81, 85, 86, 87, 89, 93, 94, 97, 101, 103, 109, 112, 113, 114, 115, 116, 117, 119, 121, 122, 123, 128, 130, 131, 132, 135, 136, 141, 144, 145, 146, 152, 153, 154, 158, 159, 164, 165, 169, 171, 172, 173, 174, 175, 179, 180, 181, 185, 186, 187, 188, 194, 195, 197, 199, 200, 203, 205, 206, 209
Streams and River Freshwater	8, 9, 12, 15, 16, 17 35, 37, 41, 51, 54, 63, 64, 65, 71, 74, 75, 76, 77, 82, 83, 84, 88, 90, 91, 92, 99, 102, 106, 107, 108, 110, 111, 134, 137, 138, 139, 142, 143, 148, 149, 156, 157, 159, 162, 166, 167, 186, 187, 189, 190, 196, 198
Lakes and Reservoirs Freshwater	4, 6, 23, 33, 34, 40, 50, 53, 60, 61, 62, 68, 95, 100, 104, 118, 125, 134, 150, 151, 160, 161, 163, 191, 193, 201, 207
Habitat Assessment	6, 17, 18, 19, 50, 55, 58, 61, 65, 84, 102, 107, 110, 112, 117, 123, 125, 131, 132, 134, 136, 144, 157, 163, 173, 179, 180, 181, 189, 201, 207
Macrophytes	18, 19, 50, 180
Periphyton	18, 19
Phytoplankton	18, 19, 180
Zooplankton	18, 19, 180
Macroinvertebrates	17, 18, 19, 107, 112, 125, 131, 144, 157, 163, 173, 179, 180, 181, 189
Fish	18, 19, 55, 65, 102, 110, 123, 125, 134, 163, 173, 179, 180, 181, 201
Other	18, 19
Population Structure	4, 7, 8, 9, 11, 12, 15, 16, 17, 18, 19, 27, 29, 39, 40, 41, 44, 45, 46, 48, 49, 50, 51, 52, 53, 58, 59, 60, 63, 66, 68, 69, 70, 71, 74, 76, 77, 78, 80, 81, 83, 85, 86, 87, 88, 89, 90, 91, 93, 95, 97, 100, 101, 103, 104, 106, 107, 108, 109, 111, 112, 113, 114, 116, 118, 125, 128, 130, 131, 137, 138, 139, 143, 144, 145, 146, 148, 151, 153, 154, 157, 159, 160, 161, 162, 167, 179, 180, 181, 185, 186, 187, 188, 189, 190, 191, 193, 196, 198, 203, 204, 205, 206
Macrophytes	18, 19, 50, 86, 180
Periphyton	18, 19, 68, 109, 154, 185, 193, 196, 203
Phytoplankton	18, 19, 160, 180, 185, 203
Zooplankton	18, 19, 160, 161, 180, 185, 203
Macroinvertebrates	7, 11, 12, 15, 16, 17, 18, 19, 29, 39, 40, 41, 45, 49, 52, 53, 58, 63, 70, 74, 76, 77, 80, 83, 85, 86, 87, 95, 97, 100, 104, 106, 107, 112, 118, 125, 128, 131, 137, 138, 139, 143, 144, 145, 148, 151, 153, 157, 159, 167, 179, 180, 181, 185, 186, 189, 191, 198, 203, 204, 205
Fish	4, 8, 9, 11, 16, 18, 19, 46, 48, 51, 54, 59, 60, 62, 66, 69, 71, 78, 81, 86, 89, 90, 91, 93, 101, 103, 108, 111, 113, 114, 125, 130, 146, 161, 162, 179, 180, 185, 188, 190, 203, 206
Other	18, 19, 185
Community Structure	4, 7, 8, 9, 11, 12, 15, 16, 17, 18, 19, 20, 27, 32, 29, 33, 34, 35, 37, 39, 41, 44, 46, 48, 49, 50, 51, 52, 53, 54, 55, 58, 60, 62, 63, 64, 65, 66, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 81, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 95, 97, 99, 100, 101, 102, 103, 104, 106, 107, 108, 109, 110, 112, 113, 114, 115, 116, 123, 125, 128, 130, 131, 132, 137, 138, 139, 141, 142, 143, 144, 145, 146, 148, 149, 150, 151, 152, 153, 156, 157, 159, 160, 161, 162, 163, 165, 166, 167, 169, 173, 179, 180, 181, 185, 186, 187, 189, 191, 194, 195, 196, 198, 200, 203, 204, 205
Macrophytes	18, 19, 33, 34, 50, 72, 86, 150, 180
Periphyton	18, 19, 32, 72, 109, 141, 149, 165, 185, 196, 199, 200, 203
Phytoplankton	18, 19, 72, 160, 180, 185, 203
Zooplankton	18, 19, 20, 72, 160, 161, 180, 185, 203

APPENDIX B

Estuarine and Near-Coastal Environments

Listing of references in the Reference Catalog for estuarine and near-coastal environments.

Catalog entries are sorted by the following major headings:

Habitat Assessment

Population Structure

Community Structure

Population and Community Interactions

Data Analysis

Interpretive Assessment

Listings under each of the major headings shown above are further sorted under the following subheadings:

Macrophytes

Periphyton

Phytoplankton

Zooplankton

Macroinvertebrates

Fish

Other

Estuarine and Near-Coastal:	10, 13, 14, 18, 19, 24, 25, 26, 28, 30, 31, 36, 38, 47, 48, 57, 58, 66, 67, 69, 73, 78, 79, 81, 85, 86, 89, 96, 116, 119, 121, 122, 127, 130, 133, 135, 136, 145, 152, 155, 158, 164, 170, 171, 172, 174, 182, 192, 206, 208, 209, 210
Habitat Assessment	10, 18, 19, 36, 58, 96, 136, 170, 182
Macrophytes	10, 18, 19
Periphyton	10, 18, 19
Phytoplankton	10, 18, 19, 96, 182
Zooplankton	10, 18, 19, 96, 182
Macroinvertebrates	10, 18, 19, 96, 170, 182
Fish	10, 18, 19, 96, 170, 182
Other	10, 18, 19
Population Structure	10, 13, 14, 18, 19, 48, 58, 66, 69, 72, 78, 81, 85, 86, 89, 96, 116, 130, 145, 147, 152, 182, 192, 206, 208, 210
Macrophytes	10, 18, 19, 86
Periphyton	10, 18, 19
Phytoplankton	10, 18, 19, 96, 192
Zooplankton	10, 18, 19, 96, 182, 192
Macroinvertebrates	10, 18, 19, 47, 67, 85, 86, 96, 133, 145, 182, 192, 208
Fish	10, 18, 19, 48, 66, 69, 78, 81, 86, 89, 96, 127, 130, 147, 182, 192, 206
Other	10, 18, 19
Community Structure	10, 13, 14, 18, 19, 48, 57, 58, 66, 69, 72, 73, 78, 81, 85, 86, 89, 96, 116, 145, 152, 170, 182, 192
Macrophytes	10, 18, 19, 86
Periphyton	10, 18, 19
Phytoplankton	10, 18, 19, 96, 182, 192
Zooplankton	10, 13, 14, 18, 19, 96, 182, 192
Macroinvertebrates	10, 18, 19, 57, 72, 73, 85, 86, 96, 145, 152, 170, 182, 192
Fish	10, 18, 19, 48, 66, 69, 78, 81, 86, 89, 96, 130, 147, 170, 182, 192
Other	10, 18, 19
Population and Community Interaction	8, 19, 66, 69, 81, 89, 96, 116, 130, 182
Macrophytes	18, 19
Periphyton	18, 19
Phytoplankton	18, 19, 96, 182
Zooplankton	18, 19, 96, 182
Macroinvertebrates	18, 19, 96, 182
Fish	18, 19, 66, 69, 81, 89, 96, 130, 147, 182
Other	18, 19
Data Analysis	10, 18, 19, 31, 38, 48, 58, 67, 78, 85, 86, 89, 116, 121, 122, 130, 145, 155, 158, 170, 171, 192, 206, 208
Macrophytes	10, 18, 19, 86

APPENDIX C

Wetland Environments

Listing of references in the Reference Catalog for estuarine and near-coastal environments.

Catalog entries are sorted by the following major headings:

Habitat Assessment

Population Structure

Community Structure

Population and Community Interactions

Data Analysis

Interpretive Assessment

Listings under each of the major headings shown above are further sorted under the following subheadings:

Macrophytes

Periphyton

Phytoplankton

Zooplankton

Macroinvertebrates

Fish

Other

Wetlands	1, 2, 3, 18, 19, 21, 22, 24, 25, 26, 30, 31, 38, 42, 43, 46, 56, 58, 73, 86, 89, 98, 103, 104, 116, 119, 120, 121, 122, 124, 126, 129, 135, 136, 140, 145, 152, 158, 164, 168, 172, 202, 206, 209
Habitat Assessment	1, 2, 3, 18, 19, 21, 22, 42, 43, 56, 58, 104, 120, 124, 126, 129, 136, 140, 168, 202
Macrophytes	1, 2, 3, 18, 19, 42, 43, 56, 120
Periphyton	18, 19
Phytoplankton	18, 19
Zooplankton	18, 19
Macroinvertebrates	18, 19, 168
Fish	1, 2, 3, 18, 19, 168
Other	1, 2, 3, 18, 19, 22, 168, 202
Population Structure	18, 19, 42, 43, 46, 58, 86, 89, 103, 116, 145, 202, 206
Macrophytes	18, 19, 42, 43, 86
Periphyton	18, 19
Phytoplankton	18, 19
Zooplankton	18, 19
Macroinvertebrates	18, 19, 86, 145
Fish	18, 19, 46, 86, 89, 103, 206
Other	18, 19, 202
Community Structure	18, 19, 22, 46, 58, 73, 86, 89, 103, 116, 145, 152, 168, 202
Macrophytes	18, 19, 86
Periphyton	18, 19
Phytoplankton	18, 19
Zooplankton	18, 19
Macroinvertebrates	18, 19, 73, 86, 145, 152, 168
Fish	18, 19, 46, 86, 89, 103, 168
Other	18, 19, 22, 168, 202
Population and Community Interaction	18, 19, 46, 89, 98, 116
Macrophytes	18, 19
Periphyton	18, 19
Phytoplankton	18, 19
Zooplankton	18, 19
Macroinvertebrates	18, 19
Fish	18, 19, 46, 89
Other	18, 19
Data Analysis	18, 19, 31, 38, 58, 86, 89, 116, 121, 122, 145, 158, 206
Macrophytes	18, 19, 86
Periphyton:	18, 19
Phytoplankton	18, 19
Zooplankton	18, 19

APPENDIX D

Alphabetical Author/Reference Number Cross-Index for the Reference Catalog

Author Index–Reference Number

APPENDIX E

Reference Catalog Entries

Reference Number – 1

1. **Basic Reference:** Adamus, P. R. 1983. "A Method for Wetland Functional Assessment: Vol. I - Critical Review and Evaluation Concepts", PB84-241157, Report from the Center of Natural Areas, South Gardner, Maine, 176 pp.
2. **Procedure Objectives:** Comprehensive review of wetland functions.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Guidance for professionals concerned with the impacts of highways on wetland systems.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
	Community Structure		Interpretive Assessment

Community Group

x	Macrophytes		Zooplankton	x	Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 2

1. **Basic Reference:** Adamus, P. R. 1983. "A Method for Wetland Functional Assessment: Vol. II - FHWA Assessment Method", PB84-241165, Report from the Center for Natural Areas, Gardner, Maine, 138 pp.
2. **Procedure Objectives:** Description of a rapid assessment procedure for screening functional values of wetlands.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Guidance for professionals concerned with the impacts of highways and wetland systems.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
	Community Structure		Interpretive Assessment

Community Group

x	Macrophytes		Zooplankton	x	Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 3

1. **Basic Reference:** Adamus, P. R., E. J. Clairain, Jr., R. D. Smith and R. E. Young. 1987. "Wetland Evaluation Technique: Vol. II - Methodology," AD-A189, Report to the Department of the Army and U.S. Department of Transportation, 206 pp.
2. **Procedure Objectives:** Outline of a wetland evaluation technique for the assessment of wetland functions and values.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Assists managers in techniques for wetland evaluation.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

x Macrophytes	Zooplankton	x Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 4

1. **Basic Reference:** Aggus, L. R., J. P. Clugston, A. Houser, R. M. Jenkins, L. E. Vogele and C. H. Walburg. 1980. "Monitoring of Fish in Reservoirs", in Biological Monitoring of Fish, C. H. Hocutt and J. R. Stauffer, Jr. Eds., D.C. Heath and Co., pp. 149-175.
2. **Procedure Objectives:** Review of fish-sampling gear and methods in terms of reservoir sampling (gillnets, trammul nets, fyke nets, trap nets, trawls, seines; rotenone, SCUBA, electrofishing).
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Various techniques discussed with respect to advantages and disadvantages in biomonitoring in reservoirs.
5. **Level of Education Needed to Perform Procedure:** Extensive knowledge of fish collection methods and identification. Also knowledge of sample design and analysis.
6. **Field Team Size:** Varies with method
7. **Collection Time Required:** Varies with method
8. **Sample Processing Time:** Varies with method
9. Data Analysis Time: Varies with method

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 5

1. **Basic Reference:** Ahlf, W. and A. Weber. 1981. "A Simple Monitoring Technique to Determine the Heavy Metal Load of Algae in Aquatic Ecosystems", Environ. Technol. Lett., 2:317-322.
2. **Procedure Objectives:** Use of standardized, uncontaminated algae grown in lab exposed to environmental contaminants to assess heavy metal load of algae.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Measures accumulation of heavy metals in algae.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
x Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 6

1. **Basic Reference:** Albert, R. C. 1986. "Effective Low-Cost Area Wide Water Quality Monitoring", in *Lake and Reservoir Management, Vol. II.*, G. Redfield, J. Taggart and L. M. Moore, Eds., North American Lake Management Society, Washington, D. C., 458 pp.
2. **Procedure Objectives:** Description of low-cost monitoring program based on water quality screening system.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** The system is a low-cost monitoring technique for water quality.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 7

1. **Basic Reference:** Anderson, J. B. and W. T. Mason, Jr. 1971. "A Comparison of Benthic Macroinvertebrates Collected by Dredge and Basket Sampler", Journal of the Water Pollution Control Federation, 40:252-259.
2. **Procedure Objectives:** Comparison of dredge and basket macroinvertebrate samples for use in large streams.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Rock basket was found to collect a more representative benthic macroinvertebrate sample than the Peterson dredge.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macrinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 8

1. Basic Reference: Angermeier, P. L. and I. J. Schlosser. 1987. "Assessing Biotic Integrity of the Fish Community in a Small Illinois Stream", North American Journal of Fisheries Management, 7:331-338.
2. **Procedure Objectives:** Comparison of IBI and Shannon-Weaver diversity index.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** IBI assessed water quality better than Shannon-weaver diversity index. IBI incorporates more information making it a better indicator of water quality.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment	x	Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 9

1. **Basic Reference:** Angermeier, P. L., and J. R. Karr. 1986. "Applying and Index of Biotic Integrity Based on Stream Fish Communities: Consideration in Sampling and Interpretation", North American Journal of Fisheries Management, 6:418-429.
2. **Procedure Objectives:** Use attributes of fish communities to assess stream degradation.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** IBI good measure of degradation and should be used in conjunction with measures of water and habitat quality.
5. **Level of Education Needed to Perform Procedure:** Experience in electrofishing procedures and safety. Experience in fish taxonomy and sample design.
6. **Field Team Size:** Three
7. **Collection Time Required:** One hour per sample (three persons)
8. **Sample Processing Time:** One hour per sample (three persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 10

1. **Basic Reference:** Baker, J. M. and W. J. Wolff, Eds. 1987. "Biological Surveys of Estuaries and Coasts", Cambridge University Press, 449 pp.
2. **Procedure Objectives:** Description of organisms and methods of sampling in estuarine ecosystems.
3. **Suitability for the Four Major Habitat Types**

   Freshwater Marine x Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Overview of sampling for estuaries and coasts.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

x Macrophytes	x Zooplankton	x Other Vertebrates
x Periphyton	x Macroinvertebrates	
x Phytoplankton	x Fish	

Reference Number – 11

1. Basic Reference: Beck, 1955. "Suggested Method for Reporting Biotic Data", Sew. Ind. Wastes, 27:1193-1197.

2. Procedure Objectives: Data repoting.

3. Suitability for the Four Major Habitat Types

x Freshwater	Marine	Estuarine	Wetlands

4. Primary Advantages and Disadvantages of the Procedure:

5. Level of Education Needed to Perform Procedure:

6. Field Team Size: NA

7. Collection Time Required: NA

8. Sample Processing Time: NA

9. Data Analysis Time:

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 12

1. Basic Reference: Beckett, D. C. and M. C. Miller. 1982. "Macroinvertebrate Colonization of Multiplate Samplers in the Ohio River: The Effect of Dams", Can. J. Fish. Aquat. Sci., 39:1622-1627.

2. Procedure Objectives: Determine the effect of dams on colonization of multiplate samplers.

3. Suitability for the Four Major Habitat Types

x Freshwater	Marine	Estuarine	Wetlands

4. Primary Advantages and Disadvantages of the Procedure: Differences were discovered in the colonization of artificial substrate in fast and slow moving currents.

5. Level of Education Needed to Perform Procedure: NA

6. Field Team Size: NA

7. Collection Time Required: NA

8. Sample Processing Time: NA

9. Data Analysis Time: NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 13

1. **Basic Reference:** Beers, J. R. and G. L. Stewart. 1967. "Micro-Zooplankton in the Euphotic Zone at Five Locations Across the California Current". J. Fish Res. Bd. Can., 24(10):2053-2068.
2. **Procedure Objectives:** Comparison of micro-zooplankton communities sampled at five locations across the California current.
3. **Suitability for the Four Major Habitat Types**

   Freshwater x Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Pumping system an effective method for sampling plankton in many different systems.
5. **Level of Education Needed to Perform Procedure:** Knowledge of pumping technique and zooplankton identification.
6. **Field Team Size:** Three
7. **Collection Time Required:** 20 - 30 minutes per sample (three persons)
8. **Sample Processing Time:** 2 - 3 hours per sample (one person)
9. **Data Analysis Time:** 2 - 4 hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes	x	Zooplankton	Other Vertebrates
	Periphyton		Macroinvertebrates	
	Phytoplankton		Fish	

Reference Number – 14

1. **Basic Reference:** Beers, J. R., G. L. Stewart and J. D. H. Strickland. 1967. "A Pumping System for Sampling Small Plankton", J. Fish. Res. Bd. Can., 24:1811-1818.
2. **Procedure Objectives:** Description of new seawater pumping system to sample plankton.
3. **Suitability for the Four Major Habitat Types**

   Freshwater x Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Pump method reduces avoidance and biases due to patchiness of plankton distribution.
5. **Level of Education Needed to Perform Procedure:** Knowledge of pumping technique ans zooplankton identification.
6. **Field Team Size:** Three
7. **Collection Time Required:** 20 - 30 minutes per sample (three persons)
8. **Sample Processing Time:** 2 - 3 hours per sample (one person)
9. **Data Analysis Time:** 2 - 4 hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes	x	Zooplankton	Other Vertebrates
	Periphyton		Macroinvertebrates	
	Phytoplankton		Fish	

Reference Number – 15

1. **Basic Reference:** Benfield, E. F., A. C. Hendricks and J. Cairns, Jr. 1974. "Proficiencies of Two Artificial Substrates in Collecting Stream Macroinvertebrates", Hydrobiologia, 45:431-440.
2. **Procedure Objectives:** Comparison of two artificial substrate - conservation webbing and cone-shaped concrete blocks with bottom net collections to determine best method.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Cone shaped artificial substrate found to be better collection device when compared to a webbing design. Diversity indices were higher for net collections.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two people
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 16

1. **Basic Reference:** Berkman, H. E., C. F. Rabeni, T. P. Boyle. 1986. Biomonitors of Stream Quality in Agricultural Areas: Fish Versus Invertebrates", Environmental Management, 10:413-419.
2. **Procedure Objectives:** Comparison of the ability of fish and macroinvertebrates to reflect habitat quality of sediment-impacted streams.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Fish found to be less effected by agricultural runoff. More of a direct effect was found with benthic macroinvertebrates.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment	x	Population and Community Interaction
x	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 17

1. **Basic Reference:** Bode, R. W. 1988. "Quality Assurance Work Plan for Biological Stream Monitoring in New York State", Bureau of Monitoring and Assessment Division of Water, New York State Department of Environmental Conservation. Albany, New York. 58 pp.
2. **Procedure Objectives:** Assessment of water quality based on samples of benthic macroinvertebrates using artificial substrate, kick-net, tissue analysis.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Uses both artificial substrate and kick-nets to collect benthic macroinvertebrates.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both collection and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or Two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

x Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 18

1. **Basic Reference:** Bray, J. R. and J. T. Curtis. 1957. "An Ordination of the Upland Forest Communities of Southern Wisconsin", Ecol. Monogr. 27:325-349.
2. **Procedure Objectives:** A comparative ranking method to evaluate similarity.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:**
5. **Level of Education Needed to Perform Procedure:**
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

x Macrophytes	x Zooplankton	x Other Vertebrates
x Periphyton	x Macroinvertebrates	
x Phytoplankton	x Fish	

Reference Number – 19

1. **Basic Reference:** Brillouin, L. 1962. *Science and Information Theory*. Academic Press, New York, NY., pp. 1-347.
2. **Procedure Objectives:** A diversity index method.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:**
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

x Macrophytes	x Zooplankton	x Other Vertebrates
x Periphyton	x Macroinvertebrates	
x Phytoplankton	x Fish	

Reference Number – 20

1. **Basic Reference:** Brock, D. A. 1977. "Comparison of Community Similarity Indexes", J. Water Pollut. Control Fed., 49:2488-2494.
2. **Procedure Objectives:** Comparison of 2 community similarity indexes based on field data.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Pinkham and Pearson's index too sensitive to rare species and not sensitive enough to dominant forms. PSC a better index. Does not rely on just one index.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	x Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 21

1. **Basic Reference:** Brown, M. T., E. M. Starnes, C. Diamond, B. Dunn, P. McKay, M. Noonan, S. Schrieber, J. Sendzimir, S. Thompson and B. Tighe. 1983. "A Wetlands Study of Seminole County. Identification, Evaluation and Preparation of Development Standards and Guidelines", Technical Report 41, Center for Wetlands Research, University of Florida.
2. **Procedure Objectives:** Description of a system to identify, evaluate and develop standards and guidelines for wetland ecosystems.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** This procedure evaluates various impacts and incorporates them into one value for an overall comparison of individual wetlands.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 22

1. **Basic Reference:** Cable, T. T., V. Black, Jr. and V. R. Holmes. 1989. "Simplified Method for Wetland Habitat Assessment", Environmental Management, 13:207-213.
2. **Procedure Objectives:** Description of a habitat assessment technique using birds as indicators of habitat quality.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** The use of birds to assess wetland habitat is quick and inexpensive.
5. **Level of Education Needed to Perform Procedure:** Knowledge of wetland habitat and bird identification.
6. **Field Team Size:** One or two
7. **Collection Time Required:** One to three hours (two persons)
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** One to two hours (one person)

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	x Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 23

1. **Basic Reference:** Cairns, J., Jr. 1988. "Politics, Economics, Science -Going Beyond Disciplinary Boundaries to Protect Aquatic Ecosystems", in *Toxic Contaminants and Ecosystems Health: A Great Lakes Focus*, M. S. Evans Ed.,Wiley and Sons, New York, NY, pp. 1-16.
2. **Procedure Objectives:** Outline problems in protecting aquatic ecosystems.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Overview of biological monitoring is presented.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure		Data Analysis
Community Structure	x	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 24

1. **Basic Reference:** Cairns, J., Jr. 1988. "What Constitutes Field Validation of Predictions Based on Laboratory Evidence", Aquatic Toxicology and Hazard Assessment, ASTM STP 971, W. J. Adams, G. A. Chapman, and W. G. Landis, Eds., American Society for Testing and Materials, pp. 361-368.
2. **Procedure Objectives:** Development of more explicit prediction and validation criteria based on laboratory data in the area of hazard evaluation.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	x Marine	x Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Difficult to validate some bioassessment methods in the real world. Single species toxicity test not a good indicator of a whole system.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure		Data Analysis
Community Structure	x	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 25

1. **Basic Reference:** Cairns, J., Jr. 1987. "Disturbed Ecosystems as Opportunities for Research in Restoration Ecology", in *Restoration Ecology*, W. R. Jordan, M. E. Gilpin and J. D. Aber, Eds., Cambridge University Press, pp. 307-320.
2. **Procedure Objectives:** Outline varieties of disturbed ecosystems available for study and draw attention to kinds of research that might be carried out on them.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Disturbed systems provide a good opportunity to study structure, function and dynamics.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 26

1. **Basic Reference:** Cairns, J., Jr. 1986. "Management of Water Quality and Natural Habitats to Enhance Both Human and Wildlife Needs", in *Environmental Regeneration II: Managing Water Resources*, John Cairns, Jr. and Ruth Patrick, Eds., Praeger Publishers, Philadelphia, PA, pp. 86-99.
2. **Procedure Objectives:** Development of biocriteria and methods of ecosystem regeneration to minimize human impact on natural habitats.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Some of the means of implementing the management of aquatic systems is discussed.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 27

1. Basic Reference: Cairns, J., Jr. 1981. "Biological Monitoring. Part VI: Future Needs", Water Research, 15:941-952.

2. Procedure Objectives: Discussion of future needs in biological assessment of pollution.

3. Suitability for the Four Major Habitat Types

x Freshwater	Marine	Estuarine	Wetlands

4. Primary Advantages and Disadvantages of the Procedure: NA

5. Level of Education Needed to Perform Procedure: NA

6. Field Team Size: NA

7. Collection Time Required: NA

8. Sample Processing Time: NA

9. Data Analysis Time: NA

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 28

1. Basic Reference: Cairns, J. Jr. and K. L. Dickson. 1980. "The ABC's of Biological Monitoring", in *Biological Monitoring of Fish*, C. H. Hocutt and J. Stauffer, Jr., Eds., D. C. Heath and Co., pp. 1-32.

2. Procedure Objectives: Discussion of general information about the biological monitoring of fish.

3. Suitability for the Four Major Habitat Types

x Freshwater	x Marine	x Estuarine	Wetlands

4. Primary Advantages and Disadvantages of the Procedure: Overview of biological monitoring and fish.

5. Level of Education Needed to Perform Procedure: NA

6. Field Team Size: NA

7. Collection Time Required: NA

8. Sample Processing Time: NA

9. Data Analysis Time: NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 29

1. **Basic Reference:** Cairns, J., Jr. and K. L. Dickson. 1971. "A Simple Method for the Biological Assessment of the Effects of Waste Discharges on Aquatic Bottom-Dwelling Organisms", J. Water Pollut. Control Fed., 43:755-772.
2. **Procedure Objectives:** Use of the sequential comparison index to assess effects of waste discharge on benthic macroinvertebrate populations.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Looks at a variety of sampling devices for benthic macroinvertebrates for use in biomonitoring.
5. **Level of Education Needed to Perform Procedure:** Knowledgeable of sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 30

1. **Basic Reference:** Cairns, J., Jr. and J. R. Pratt. 1987. "Ecotoxicological Effect Indices: A Rapidly Evolving System", Wat. Sci. Tech., 19(11):1-12.
2. **Procedure Objectives:** Use of micro and mesocosms to serve as complex natural communities for testing and validating predictions.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Using test situations that closely resemble the real world improves the final results.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 31

1. **Basic Reference:** Cairns, J., Jr. and J. R. Pratt. 1986. "Developing a Sampling Strategy in Rationale for Sampling and Interpretation of Ecological Data", The Assessment of Freshwater Ecosystems, ASTM STP 894, B. G. Isom Ed., American Society for Testing and Materials, pp. 168-186.
2. **Procedure Objectives:** Considerations in developing a sampling strategy for aquatic ecosystems with emphasis on data analysis and collection.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Keys to developing a sampling strategy are discussed.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure	x	Data Analysis
Community Structure	x	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 32

1. **Basic Reference:** Cairns, J. Jr., D. L. Kuhn and J. L. Plafkin. 1979. "Protozoan Colonization of Artificial Substrates", Methods and Measurements of Periphyton Communities: A Review, ASTM STP 690, R. C. Weitzel, Ed., American Society for Testing and Materials, pp. 34-57.
2. **Procedure Objectives:** Analyzing and interpreting variations in the dynamics of species accrual.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Artificial substrates collect different trophic levels in one collection device.
5. **Level of Education Needed to Perform Procedure:** Knowledge in sampling with artificial substrates and identification of periphyton taxa.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 5 - 10 minutes per sample (two persons)
8. **Sample Processing Time:** One to two hours per sample (one person)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure		Data Analysis
x Community Structure		Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
x Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 33

1. **Basic Reference:** Canfield, D. E., Jr. and J. R. Jones. 1984. "Assessing the Trophic Status of Lakes with Aquatic Macrophytes", in *Lake and Reservoir Management - Vol. I*, pp. 446-450.
2. **Procedure Objectives:** Using nutrients in macrophytes and water with existing classification systems to determine the trophic status of lakes.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Use of macrophytes along with water conditions give a better classification of lake trophic status.
5. **Level of Education Needed to Perform Procedure:** Knowledge of aquatic plant sampling and identification. Also knowledge of techniques for measuring potential phosphorus content.
6. **Field Team Size:** Two to three
7. **Collection Time Required:** Variable
8. **Sample Processing Time:** Variable
9. **Data Analysis Time:** Variable

Subsection

	Habitat Assessment	Population and Community Interaction
	Population Structure	Data Analysis
x	Community Structure	Interpretive Assessment

Community Group

x	Macrophytes	Zooplankton	Other Vertebrates
	Periphyton	Macroinvertebrates	
	Phytoplankton	Fish	

Reference Number – 34

1. **Basic Reference:** Carlson, R. E. 1984. "The Trophic State Concept: A Lake Management Perspective", in *Lake and Reservoir Management - Vol. I*, pp. 427-429.
2. **Procedure Objectives:** Describes the confusion over the term trophic state, stemming from overabundance of definitions.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Use of macrophytes to assess trophic status as one way to simplify confusion.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment	Population and Community Interaction
	Population Structure	Data Analysis
x	Community Structure	Interpretive Assessment

Community Group

x	Macrophytes	Zooplankton	Other Vertebrates
	Periphyton	Macroinvertebrates	
	Phytoplankton	Fish	

Reference Number – 35

1. **Basic Reference:** Chadwick, J. W. and S. P. Canton. 1984. "Inadequacy of Diversity Indices in Discerning Metal Mine Drainage Effects on Stream Invertebrate Community", Water, Air, Soil Pollution, 22:217-233.
2. **Procedure Objectives:** Description of the failure of several biotic indices to correctly assess water quality in a stream subject to metal mine drainage.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Diversity indices found to be inadequate in assessing the effects of mine drainage.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 36

1. **Basic Reference:** Chesapeake Executive Council. 1988. "Habitat Requirements For Chesapeake Bay Living Resources", Chesapeake Bay Program, Agreement Commitment Report, Annapolis, MD., 86 pp.
2. **Procedure Objectives:** To establish a technically defensible approach in setting regional habitat objectives for Chesapeake Bay by initially assembling habitat requirements for individual target species.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	x Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 37

1. **Basic Reference:** Chutter, F. M. 1972. "An Empirical Biotic Index of the Quality of Water in South African Streams and Rivers", Water Research, 6:19-30.
2. **Procedure Objectives:** Reducing data on stones-in-current faunal communities to a linear scale of water quality in terms of organic pollution.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** The biotic index value BIU is compared with other indices.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
x	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 38

1. **Basic Reference:** Cochran, W. G. 1963. *Sampling Techniques.* Wiley, New York, NY.
2. **Procedure Objectives:** An overview of statistical validation of sampling techniques.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment		Population and Community Interaction
	Population Structure	x	Data Analysis
	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 39

1. **Basic Reference:** Cook, S. E. K. 1976. "Quest for an Index of Community Structure Sensitive to Water Pollution", Environ. Pollut., 11:269-288.
2. **Procedure Objectives:** Review of indices for summarizing benthic macroinvertebrate data and description of results of a field test.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Indices found to be variable in assessing environmental disturbances. Shannon-Weaver index found to be imprecise while the modified Chandler score was found to be the most reliable.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 40

1. **Basic Reference:** Courtemanch, D. 1987. "Trophic Classification of Maine Lakes Using Benthic Chironomid Fauna", Maine Department of Environmental Protection, Augusta, Maine. (Submitted to Lake and Reservoir Mananagement)
2. **Procedure Objectives:** Trophic classification based on benthic chironomids as they relate to chlorophyll a and phosphorus content.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Benthic chironomids were a good indicator of lake trophic level.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** One to eight hours per sample (one person)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 41

1. **Basic Reference:** Courtemanch, D. L. 1984. "A Closing Artificial Substrate Device for Sampling Benthic Macroinvertebrates in Deep Rivers", Freshwater Invertebrate Biology, 3(3):143-146.
2. **Procedure Objectives:** Artificial substrate device to collect benthic macroinvertebrates from deep rivers with minimal loss of organisms.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** A closing artificial substrate was found to be effective in reducing sample loss during retrieval.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One to two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 42

1. **Basic Reference:** Cowardin, L. M. 1978. "Wetland Classification in the United States", Journal of Forestry, 76:666-668.
2. **Procedure Objectives:** Description of a hierarchical classification system for wetlands.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Classification of wetlands help managers in managing these systems.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

x Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 43

1. **Basic Reference:** Cowardin, L. M., V. Carter, F. C. Golet and E. T. LaRoe. 1979. "Classification of Wetlands and Deepwater Habitats of the United States", U.S. Fish and Wildlife Service, 103 pp.
2. **Procedure Objectives:** Criteria for the classification of wetlands and deepwater habitats.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Classification of wetlands and deepwater habitats help managers in managing these systems.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction	
x Population Structure	Data Analysis	
Community Structure	Interpretive Assessment	

Community Group

x Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 44

1. **Basic Reference:** Crossman, J. S. and J. Cairns, Jr. 1974. "A Comparative Study Between Two Different Artificial Substrate Samplers and Regular Sampling Techniques", Hydrobiologia, 44:517-522.
2. **Procedure Objectives:** Comparison between 2 artificial sampling methods and regular sampling techniques to determine most efficient method.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** A comparison of two different types of artificial substrates is examined.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction	
x Population Structure	Data Analysis	
x Community Structure	x Interpretive Assessment	

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 45

1. **Basic Reference:** Cushman, R. M. 1984. "Chironomid Deformities as Indicators of Pollution from a Synthetic, Coal-Derived Oil", Freshwater Biology, 14:179-182.
2. **Procedure Objectives:** Description of study relating chironomid deformities to oil pollution.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Chironomid deformities found to be less sensitive than population structure in assessing oil pollution.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 46

1. **Basic Reference:** Davies, W. D. 1983. "Sampling with Toxicants", in *Fisheries Techniques*, L. A. Nielsen and D. L. Johnson, Eds., American Fisheries Society, Bethesda, Maryland, pp. 199-214.
2. **Procedure Objectives:** Discussion of the various aspects of sampling fish populations with approved toxicants.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Overview of the use of toxicants. Non-selective method but labor intensive. May be public relations problems.
5. **Level of Education Needed to Perform Procedure:** Knowledge of the use of fish toxicants, sample design and fish identification.
6. **Field Team Size:** 5 to 10
7. **Collection Time Required:** Two to four hours per sample (5 - 10 persons)
8. **Sample Processing Time:** 4 - 6 hours per sample (5 - 7 persons)
9. **Data Analysis Time:** 3 - 6 hours per sample (one person)

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 47

1. **Basic Reference:** DeGoursey, R. E., J. K. Watson, R. V. Grillo, R. Arimoto and S. Y. Feng. 1984. "Field Techniques for In-Situ Long Term Monitoring of the Effects of Dredged Material Disposal on the Mussel, *Mytilus edulis*", Mar. Technol. Soc. Journal, 18(4):9-16.
2. **Procedure Objectives:** Monitor environmental contaminates in mussels using free standing PVC platform at disposal site.
3. **Suitability for the Four Major Habitat Types**

Freshwater	x Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** The advantages of a platform for mussels to monitor the effects of pollutants such as heavy metals from dredged material disposal sites.
5. **Level of Education Needed to Perform Procedure:** Knowledge of mussel biology and sampe design. Also analytical background for metals extraction.
6. **Field Team Size:** Two or three
7. **Collection Time Required:** 30 - 60 minutes per sample (three persons)
8. **Sample Processing Time:** Variable
9. **Data Analysis Time:** 2 - 4 hours (one person)

Subsection

	Habitat Assessment	Population and Community Interaction
x	Population Structure	Data Analysis
	Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 48

1. **Basic Reference:** Demory, R. L. and J. T. Golden. 1983. "Sampling the Commercial Catch", in *Fisheries Techniques*, L. A. Nielsen and D. L. Johnson, Eds., American Fisheries Society, Bethesda, Maryland, pp. 421-430.
2. **Procedure Objectives:** Discussion of approaches to obtaining harvest statistics through census and sampling of the commercial catch.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	x Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Use of surveys to collect information about commercial fisheries is an inexpensive method to collect a wide variety of information. Can have problems with survey biases.
5. **Level of Education Needed to Perform Procedure:** Knowledge of survey design.
6. **Field Team Size:** One
7. **Collection Time Required:** One to two hours per sample (one person)
8. **Sample Processing Time:** Two to four hours per sample (one person)
9. **Data Analysis Time:** Two to four hours (one person)

Subsection

	Habitat Assessment	Population and Community Interaction
x	Population Structure	x Data Analysis
x	Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 49

1. **Basic Reference:** DePauw, N., D. Roels and A. P. Fontoura. 1986. "Use of Artificial Substrates for Standardized Sampling of Macroinvertebrates in the Assessment of Water Quality by the Belgian Biotic Index", Hydrobiologia, 133:237-258.
2. **Procedure Objectives:** Description of the uses of the Belgian biotic index to assess water quality.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Able to use artificial substrates in different water courses to obtain a quantitative sample for water quality assessment.
5. **Level of Education Needed to Perform Procedure:** Knowledge of sampling and identification of benthic macroinvertebrates using artificial substrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** One or two hours per sample (two persons)
9. **Data Analysis Time:** 2 - 4 hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 50

1. **Basic Reference:** Edmiston, H. L. and V. B. Myers. 1984. "Florida Lakes Assessment: Combining Macrophyte, Chlorophyll, Nutrient and Public Benefit Parameters into a Meaningful Lake Management Scheme", Lake and Reservoir Management - Vol. I, Bureau of Water Management, Florida Department of Environmental Regulation, Tallahassee, Florida.
2. **Procedure Objectives:** Assessment of lake water quality based on several biotic and chemical indices.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Use of macrophyte abundance along with secci disk, chlorophyll a , total phosphorus and nitrogen concentrations give good indication of trophic status.
5. **Level of Education Needed to Perform Procedure:** Knowledge of macrophyte sampling and identification, nutrient sampling, and chlorophyll a analysis.
6. **Field Team Size:** Two or three
7. **Collection Time Required:** Two to four hours per sample (three persons)
8. **Sample Processing Time:** Two to four hours per sample (one person)
9. **Data Analysis Time:** One or two hours (one person)

Subsection

x	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

x	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 51

1. **Basic Reference:** Fausch, K. D., J. R. Karr and P. R. Yant. 1984. "Regional Application of an Index of Biotic Integrity Based on Stream Fish Communities", Trans. Am. Fish. Soc., 113:39-55.
2. **Procedure Objectives:** Use basic relationships of fish species richness versus stream size, calculated from historical fish community data for watersheds to define lines of maximum species richness.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Five of the IBI (Index of Biotic Integrity) metrics were found to need adjustment for different zoogeographic regions.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 52

1. **Basic Reference:** Fullner, R. W. 1971. "A Comparison of Macroinvertebrates Collected by Basket and Modified Multi-Plate Samplers", Journal of the Water Pollution Control Federation, 43:494-499.
2. **Procedure Objectives:** Comparison of basket and multi-plate sampling for aquatic macroinvertebrates.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** The multi-plate sampler collected less insect larvae than the rock basket, but this was not enough to eliminate the multi-plate sampler as a good collection method for water quality monitoring.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 53

1. **Basic Reference:** Furse, M. T., J. F. Wright, P. D. Armitage, and D. Moss. 1981. "An Appraisal of Pond-Net Samples for Biological Monitoring of Lotic Macroinvertebrates", Water Research, 15:679-689.
2. **Procedure Objectives:** Determine accuracy of a sampling technique by conducting a field trial on a river in England.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Kick-nets had some disadvantages in sampler bias but this bias was not enough to change data when statistically analyzed. Three minute samples collected 50% of the species and 62% of the families that could be obtained in a 18 minute sample.
5. **Level of Education Needed to Perform Procedure:** Knowledge in both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minute per sample (one person)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 54

1. **Basic Reference:** Gammon, J. R., A. Spacie, J. L. Hamelink, and R. L. Kaesler. 1981. "Role of Electrofishing in Assessing Environmental Quality of the Wabash River", in *Ecological Assessments of Effluent Impacts on Communities of Indigenous Aquatic Organisms*, ASTM STP 730, American Society for Testing and Materials, pp. 307-324.
2. **Procedure Objectives:** Analysis of fish samples (collected by electroshocking) with cluster analysis and community and composite indices to assess water quality.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Good procedure for collecting fish samples from a river system for biomonitoring; can be moderately labor and time intensive.
5. **Level of Education Needed to Perform Procedure:** Experience in electrofishing procedures and safety. Experience in fish taxonomy and sample design and analysis.
6. **Field Team Size:** Three
7. **Collection Time Required:** One hour per sample (three persons)
8. **Sample Processing Time:** One hor per sample (three persons)
9. **Data Analysis Time:** 5 - 10 hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 55

1. **Basic Reference:** Gilbert, C. R. 1980. "Zoogeographic Factors in Relation to Biological Monitoring of Fish", in *Biological Monitoring of Fish*, C. H. Hocutt and J. Stauffer, Jr. Eds., D. C. Heath and Co., pp. 309-356.
2. **Procedure Objectives:** Role of zoogeography in the interpretation and comparison of biotas from different areas.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Overview of zoogeographic factors in relation to biological monitoring.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 56

1. Basic Reference: Glooschenko, V. 1983. "Development of an Evaluation System for Wetlands in Southern Ontario", Wetlands, 3:192-200.
2. **Procedure Objectives:** Description of a quantitative system for wetland evaluation.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Provides professionals with framework to use in wetland management.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

x Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 57

1. **Basic Reference:** Goddard, C. I., M. H. Goodwin and L. A. Greig. 1975. "The Use of Artificial Substrates in Sampling Estuarine Benthos", Trans. Am. Fish. Soc., 104:50-52.
2. **Procedure Objectives:** Comparison between density estimates of estuarine benthos based on artificial substrate sampling and diver estimation.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	x Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Artificial substrate may preferentially sample certain portions of the benthic population. Diving is expensive and is prone to sampler bias.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 58

1. **Basic Reference:** Green, R. H. 1978. "Optimal Impact Study Design and Analysis", in *Biological Data in Water Pollution Assessment: Quantitative and Statistical Analyses*, K. L. Dickson, J. Cairns, Jr., and R. L. Livingston, Eds., ASTM STP 652, American Society for Testing and Materials, Philadelphia, PA., pp. 3-28.
2. **Procedure Objectives:** To discuss study design in the evaluation of pollution impact.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	x Marine	x Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 59

1. **Basic Reference:** Gruber, D. and J. Cairns, Jr. 1981. "Industrial Effluent Monitoring Incorporating a Recent Automated Fish Biomonitoring System", Water, Air and Soil Pollution, 15(4):471-481.
2. **Procedure Objectives:** Assessment of water quality by automated monitoring of fish ventilatory behavior.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Detailed information of fish physiology and waste water discharge. Very capital intensive (equipment) time intensive.
5. **Level of Education Needed to Perform Procedure:** Extensive knowledge on computer and fish monitoring equipment (automated fish biomonitoring system). Knowledge of fish physiology and effluent testing.
6. **Field Team Size:** One or two
7. **Collection Time Required:** Collected by computer
8. **Sample Processing Time:** Automated
9. **Data Analysis Time:** Two to six hours

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure		Data Analysis
	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 60

1. **Basic Reference:** Gunn, J. M., L. E. Mackey, L. I. Deacon, T. J. Stewart, F. J. Hicks, B. P. Munroe, G. L. Boggs. 1988. "Long Term Monitoring of Fish Communities in Acid Sensitive Lakes in Ontario", Lake and Reservoir Management, 4(1):123-134.
2. **Procedure Objectives:** Monitor fish communities for presence, abundance, age, composition, growth, recruitment to assess acid deposition effects.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Long term projects yield extensive data but are time and labor intensive and results and conclusions take time to develop.
5. **Level of Education Needed to Perform Procedure:** Extensive knowledge on fish sampling and analytical techniques. Knowledge on sampling design and analysis.
6. **Field Team Size:** Three or more
7. **Collection Time Required:** One to five hours for 10 - 600 ha lake

(three persons)

8. **Sample Processing Time:** Two to six hours for 10 - 600 ha lake (three persons)
9. **Data Analysis Time:** 10 - 20 hours (one person)

Subsection

	Habitat Assessment	x	Population and Community Interaction
x	Population Structure		Data Analysis
x	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 61

1. **Basic Reference:** Hanson, M. J., H. G. Stefan and M. Riley. 1986. "Dynamic (Mathematical) Modeling of Lake Processes for Management Decisions", in *Lake and Reservoir Management - Vol. II*, G. Redfield, J. Taggart and L. M. Moore, Eds., North American Lake Management Society, Washington, D. C., 458 pp.
2. **Procedure Objectives:** Describes lake management model which simulates changes in physical, chemical and biological lake parameters with depth and time variability.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Do not have to do actual sampling. Able to test many different scenarios at low cost. These are not "real world" situations.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 62

1. **Basic Reference:** Hartman, W. L. 1980. "Fish-Stock Assessment in the Great Lakes", in *Biological Monitoring of Fish*, C. H. Hocutt and J. Stauffer, Jr. Eds., D. C. Heath and Co., pp. 119-148.
2. **Procedure Objectives:** Description of the application of fish-stock information to assess resource management problems.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Overview of the biological monitoring of the Great Lakes.
5. **Level of Education Needed to Perform Procedure:** Knowledge of Great Lakes fish sampling techniques and identification.
6. **Field Team Size:** Varies with method
7. **Collection Time Required:** Varies with method
8. **Sample Processing Time:** Varies with method
9. **Data Analysis Time:** Varies with method

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 63

1. **Basic Reference:** Hawkes, H. A. 1979. "Invertebrates as Indicators of River Water Quality", in *Biological Indices of Water Quality*, Chapter 2, A. James and L. Evison, Eds., John Wiley and Sons, New York, NY., pp. 1-45.
2. **Procedure Objectives:** Provides a general overview of several methods employing invertebrates as biological indicators.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:**
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 64

1. **Basic Reference:** Hawkes, H. A. 1977. "Biological Classification of Rivers: Conceptual Basis and Ecological Validity", In *Biological Monitoring of Inland Fisheries*, J.S. Alabaster, Ed., Applied Science Publishers, London, pp. 55-67.
2. **Procedure Objectives:** Determine ecological validity of several different types of indices used in classification of river water quality.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** The need for educated use of biological data is emphasized when using benthic macroinvertebrates in biomonitoring.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 65

1. **Basic Reference:** Hawkes, C. L., D. L. Miller, W. G. Layher. 1986. "Fish Ecoregions of Kansas: Stream Fish Assemblage Patterns and Associated Environmental Correlates", Env. Biol. Fishes, 17:267-279.
2. **Procedure Objectives:** Determine environmental characteristic which affects fish assemblage patterns.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Value of ecoregions will enable researchers to develop a better ability to assess and manage fish populations.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 66

1. **Basic Reference:** Hayes, J. L. 1983. "Active Fish Capture Methods", in *Fisheries Techniques*, L. A. Nielsen and D. L. Johnson, Eds., American Fisheries Society, Bethesda, Maryland, pp. 123-146.
2. **Procedure Objectives:** Provide information needed to select, construct and operate active fishing gear to sample fish and macroinvertebrate in a wide range of habitats.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Overview of active sampling gear. More labor intensive than passive gear. Less selective but still has biases.
5. **Level of Education Needed to Perform Procedure:** Extensive knowledge of fish collection methods and identification. Also knowledge of sample design and analysis.
6. **Field Team Size:** Variable
7. **Collection Time Required:** Variable
8. **Sample Processing Time:** Variable
9. **Data Analysis Time:** Variable

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 67

1. **Basic Reference:** Heip, C. 1984. "Nematode Species Abundance Patterns and Their Use in the Detection of Environmental Perturbations", Hydrobiologia, 118(1):59-66.
2. **Procedure Objectives:** Diversity comparisons based on assessment of shifts in dominance patters to be used with Simpson's dominance-weighted diversity index for assessment of marine pollutant impacts.
3. **Suitability for the Four Major Habitat Types**

Freshwater	x Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Use of all species in diversity indices instead of single groups is discussed.
5. **Level of Education Needed to Perform Procedure:** Knowledge in benthic macroinvertebrate sampling and nematode identification.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** One to two hours per sample (one person)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 68

1. **Basic Reference:** Heiskary, S. and W. W. Walker, Jr. 1987. "Developing Phosphorus Criteria for Minnesota Lakes", Presented at The Annual Symposium of the North American Lake Management Society, Orlando, Florida, 17 pp.
2. **Procedure Objectives:** Lake management strategies based on assessment of phosphorus impacts on lake condition.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Use of chlorophyll a (blooms), reduced transparency and user-perceived impairment can be used to set phosphorus criteria.
5. **Level of Education Needed to Perform Procedure:** Knowledge of chlorophyll a measurements and survey design.
6. **Field Team Size:** Variable
7. **Collection Time Required:** Variable
8. **Sample Processing Time:** Variable
9. **Data Analysis Time:** Variable

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure		Data Analysis
	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
x	Periphyton		Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 69

1. **Basic Reference:** Helfman, G. S. 1983. "Underwater Methods", in *Fisheries Techniques*, L. A. Nielsen and D. L. Johnson, Eds., American Fisheries Society, Bethesda, Maryland, pp. 349-369.
2. **Procedure Objectives:** Discussion of techniques involved in observation of fish populations by divers.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine Estuarine Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Use of underwater methods to sample and observe fish populations. Can collect data other methods, but special training is needed.
5. **Level of Education Needed to Perform Procedure:** Extensive knowledge of the use of SCUBA in fish collection and observation. Also knowledge of sample design and analysis.
6. **Field Team Size:** Varies with method
7. **Collection Time Required:** Variable
8. **Sample Processing Time:** Variable
9. **Data Analysis Time:** Variable

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 70

1. **Basic Reference:** Hellawell, J. 1977. "Biological Surveillance and Water Quality Monitoring", in *Biological Monitoring of Inland Fisheries*, J. S. Alabaster, Ed., Applied Science Publishers, London, pp. 69-88.
2. **Procedure Objectives:** Evaluation of macroinvertebrate biological surveillance in water quality monitoring.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Macroinvertebrates recommended in biomonitoring. Need to sample enough are to reduce bias due to patchy distribution. Use a variety of sampling devices to cover all habitats. Diversity indices best method for analysis.
5. **Level of Education Needed to Perform Procedure:** Knowledge of benthic macroinvertebrate sampling and identification.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 71

1. **Basic Reference:** Hendricks, M. L., C. H. Hocutt and J. R. Stauffer, Jr. 1950. "Monitoring of Fish in Lotic Habitats", in *Biological Monitoring of Fish*, C. H. Hocutt and J. R. Stauffer, Jr., Eds., D.C. Heath and Co., Lexington, MA., 416 pp.
2. **Procedure Objectives:** Use of gill nets, trap nets, seines, electroshocking and ichthyocides to collect fish for species analysis.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Explains advantages/disadvantages of fish collection methods in biomonitoring of flowing waters.
5. **Level of Education Needed to Perform Procedure:** Extensive knowledge of fish collection methods and identification. Also knowledge of sample design and analysis.
6. **Field Team Size:** Varies with method
7. **Collection Time Required:** Varies
8. **Sample Processing Time:** Varies
9. **Data Analysis Time:** Varies

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 72

1. **Basic Reference:** Herricks, E. E. and J. Cairns, Jr. 1982. "Biological Monitoring. Part III: Receiving System Methodology Based on Community Structure", Water Research, 16:141-153.
2. **Procedure Objectives:** Description of the use and limitations of data that describe the structure of aquatic communities.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Need to develop information that will allow the quantification of cause and effect relationships.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

x Macrophytes	x Zooplankton	x Other Vertebrates
x Periphyton	x Macroinvertebrates	
x Phytoplankton	x Fish	

Reference Number – 73

1. **Basic Reference:** Hester, F. E. and J. S. Dendy. 1962. "A Multiple-Plate Sampler for Aquatic Macroinvertebrates", Trans. Amer. Fish. Soc., 91:420-421.
2. **Procedure Objectives:** Multi-plate sampler to act as artificial substrate for aquatic macroinvertebrates.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** The multi-plate sampler was found to be simple to use, quantitative, and a good sampling device for collecting a variety of macroinvertebrates.
5. **Level of Education Needed to Perform Procedure:** Knowledge of benthic macroinvertebrate sampling and identification.
6. **Field Team Size:** One to two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment	Population and Community Interaction
	Population Structure	Data Analysis
x	Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 74

1. **Basic Reference:** Hilsenhoff, W. L. 1988. "Rapid Field Assessment of Organic Pollution with a Family-level Biotic Index", Journal of the North American Benthological Society, 7(1):65-68.
2. **Procedure Objectives:** Determine biotic integrity of macroinvertebrates to provide a rapid, but less critical evaluation of streams using arthropods.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** It is a quicker approach but this technique loses some accuracy in the process.
5. **Level of Education Needed to Perform Procedure:** Knowledge of benthic macroinvertebrate sampling and identification.
6. **Field Team Size:** One or Two
7. **Collection Time Required:** 5 - 10 minutes per station (two persons)
8. **Sample Processing Time:** 15 - 30 minutes per sample (two persons)
9. **Data Analysis Time:** 30 - 60 minutes (one person)

Subsection

	Habitat Assessment	x Population and Community Interaction
x	Population Structure	x Data Analysis
x	Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 75

1. **Basic Reference:** Hilsenhoff, W. L. 1987. "An Improved Biotic Index of Organic Stream Pollution", Great Lakes Entomologist, 20:31-39.
2. **Procedure Objectives:** Improved biotic index of arthropod fauna to evaluate organic stream pollution.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Use of arthropods to assess organic pollution is fast but restricted in its use.
5. **Level of Education Needed to Perform Procedure:** Knowledge of collection of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 5 - 10 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** 30 - 60 minutes (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
	Population Structure	x	Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton	Other Vertebrates
	Periphyton	x	Macroinvertebrates	
	Phytoplankton		Fish	

Reference Number – 76

1. **Basic Reference:** Hilsenhoff, W. L. 1982. "Using a Biotic Index to Evaluate Water Quality in Streams", Technical Bulletin No. 132, Wisconsin Department of Natural Resources, Madison, WI., 23 pp.
2. **Procedure Objectives:** Utilizes macroinvertebrate community structure to provide an index of water quality.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:**
5. **Level of Education Needed to Perform Procedure:**
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment	x	Population and Community Interaction
x	Population Structure		Data Analysis
x	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton	Other Vertebrates
	Periphyton	x	Macroinvertebrates	
	Phytoplankton		Fish	

Reference Number – 77

1. **Basic Reference:** Hilsenhoff, W. L. 1977. "Use of Arthropods to Evaluate Water Quality of Streams", Technical Bulletin No. 100, Wisconsin Department of Natural Resources, Madison, WI., 15 pp.
2. **Procedure Objectives:** Utilizes macroinvertebrate community structure to evaluate stream water quality.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 78

1. **Basic Reference:** Hocutt, C. H. and J. Stauffer, Jr., Eds. 1980. *Biological Monitoring of Fish.* D. C. Heath and Co.
2. **Procedure Objectives:** An overview of different biological monitoring methods using fish.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	x Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 79

1. **Basic Reference:** Holme, N. A. and A. D. McIntyre, Eds. 1984. "Methods for the Study of Marine Benthos", 2nd Edition, Blackwell Scientific Publications, Boston, MA., 387 pp.
2. **Procedure Objectives:** Description of techniques for sampling marine benthos.
3. **Suitability for the Four Major Habitat Types**

Freshwater	x	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Overview of sampling methods for marine benthos.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction	
Population Structure		Data Analysis	
Community Structure	x	Interpretive Assessment	

Community Group

Macrophytes		Zooplankton	Other Vertebrates
Periphyton	x	Macroinvertebrates	
Phytoplankton		Fish	

Reference Number – 80

1. **Basic Reference:** Howmiller, R. P. and M. A. Scott. 1977. "An Environmental Index Based on Relative Abundance of Oligachaete Species", J. Water Pollut. Control Fed., 49:809-815.
2. **Procedure Objectives:** Description of several types of proposed indices distinguished by the sort of information they summarize.
3. **Suitability for the Four Major Habitat Types**

x	Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Discussion of several indices and the use of oligochaete species to detect water quality changes.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction	
x Population Structure	x	Data Analysis	
Community Structure	x	Interpretive Assessment	

Community Group

Macrophytes		Zooplankton	Other Vertebrates
Periphyton	x	Macroinvertebrates	
Phytoplankton		Fish	

Reference Number – 81

1. **Basic Reference:** Hubert, W. A. 1983. "Passive Capture Techniques", in *Fisheries Techniques*, L. A. Nielsen and D. L. Johnson, Eds., American Fisheries Society, Bethesda, Maryland, pp. 95-122.
2. **Procedure Objectives:** Description, advantages and disadvantages and equipment involved in several passive capture techniques.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	x Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Overview of passive capture techniques. Easy to use but gear has biases.
5. **Level of Education Needed to Perform Procedure:** Extensive knowledge of fish collection methods and identification. Also knowledge of sample design and analysis.
6. **Field Team Size:** Varies with method
7. **Collection Time Required:** Variable
8. **Sample Processing Time:** Variable
9. **Data Analysis Time:** Variable

Subsection

Habitat Assessment	x	Population and Community Interaction
x Population Structure		Data Analysis
x Community Structure		Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 82

1. **Basic Reference:** Hughes, B. D. 1978. "The Influence of Factors Other Than Pollution on the Value of Shannon's Diversity Index for Benthic Macroinvertebrates in Streams", Water Research, 12:359-364.
2. **Procedure Objectives:** The effects of six factors on the value of Shannon's diversity index were examined using field data from a polluted river.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure		Data Analysis
x Community Structure	x	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 83

1. **Basic Reference:** Hughes, B. D. 1975. "A Comparison of Four Samplers for Benthic Macroinvertebrates Inhabiting Coarse River Deposits", Water Research, 9:61-69.
2. **Procedure Objectives:** Comparison of four different macroinvertebrate sampling devices for coarse river deposits.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** The surber and box samplers were found to be better than the electric shock sampler and the artificial substrate.
5. **Level of Education Needed to Perform Procedure:** Knowledge of benthic macroinvertebrate sampling methods and identification.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 84

1. **Basic Reference:** Hughes, R. M., D. P. Larsen and J. M. Omernik. 1986. "Regional Reference Sites: A Method for Assessing Stream Potentials", Environmental Management, 10:629-635.
2. **Procedure Objectives:** Set up regional reference sites to act as controls in the field assessment of impacted streams.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Ecoregions advantageous for using as control sites to compare to suspected impacted sites.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 85

1. **Basic Reference:** Hulbert, J. L. 1987. "Biological Standards in the Florida Water Quality Rules", Presented at the U.S. EPA, Biocriteria Workshop, Chicago, Illinois, December 2-4.
2. **Procedure Objectives:** Determine the biological integrity of benthic macroinvertebrates using Shannon-Weaver index. Using artificial substrate and ponar type sampler.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Natural grabs better for lakes but forced to use artificial substrate. Use natural grabs for marine environments. Shannon-Weaver has some problems. This is a start for Biocriteria in Florida.
5. **Level of Education Needed to Perform Procedure:** Knowledge about sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons).
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons).
9. **Data Analysis Time:** One to two hours (one person).

Subsection

Habitat Assessment	Population and Community Interaction	
x Population Structure	x Data Analysis	
x Community Structure	Interpretive Assessment	

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 86

1. **Basic Reference:** Jaccard, P. 1908. "Nouvelles Recherches sur la Distribution Florale", Bull. Soc. Vaud. Sci. Nat., XLIV(163):223-269.
2. **Procedure Objectives:** Provides a coefficient that can be used to compare the similarity of communities.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction	
x Population Structure	x Data Analysis	
x Community Structure	Interpretive Assessment	

Community Group

x Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 87

1. **Basic Reference:** Jarrett, F. L., K. B. Grogan, D. L. Martin and J. W. McIntosh, Jr. 1975. "Use of Artificial Substrate for Sampling Macroinvertebrate Organisms", The Virginia Journal of Science, 26:56.
2. **Procedure Objectives:** Comparison of net versus Plate artificial substrate sampler.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Two artificial substrate designs are compared to samples collected with a surber sampler.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 88

1. **Basic Reference:** Kaesler, R. L., E. E. Herricks and J. S. Crossman. 1978. "Use of Indices of Diversity and Hierarchical Diversity in Stream Surveys", in *Biological Data in Water Pollution Assessment: Quantitative and Statistical Analysis*, ASTM STP 652, K. L. Dickson, J. Cairns, Jr., and R. J. Livingston, Eds., American Society for Testing and Materials, pp. 72-112.
2. **Procedure Objectives:** Comparison of Brillouins equation with other equations of species diversity in stream systems.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Use of generic diversity as opposed to species diversity revealed similar results and saves time and money. Hierarchal diversities show promise in the future.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 89

1. **Basic Reference:** Karr, J. R. 1987. "Biological Monitoring and Environmental Assessment: A Conceptual Frame Work", Environmental Management, 11(2):249-256.
2. **Procedure Objectives:** Importance of biological monitoring with emphasis on metrics like the IBI (Index of Biotic Integrity).
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine x Estuarine x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** IBI takes into account individual, population, community and ecosystem attributes.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 90

1. **Basic Reference:** Karr, J. R., P. R. Yant, K. D. Fausch, and I. J. Schlosser. 1987. "Spatial and Temporal Variability of the Index of Biotic Integrity in Three Midwestern Streams", Transactions of the American Fisheries Society, 116:1-11.
2. **Procedure Objectives:** Use of IBI for comparison over time and between sites.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Consistently ranked sites. Sampling should be done during summer.
5. **Level of Education Needed to Perform Procedure:** Experience in the concept of the IBI and fish identification. Knowledge in the use of electrofishing techniques.
6. **Field Team Size:** Three
7. **Collection Time Required:** One hour per sample (three persons)
8. **Sample Processing Time:** One hour per sample (three persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 91

1. Basic Reference: Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, I. J. Schlosser. 1986. "Assessing Biological Integrity in Running Waters a Method and Its Rational", Special Publication 5, Illinois Natural History Survey, Urbana, Illinois.
2. **Procedure Objectives:** The use of the Index of Biotic Integrity to determine the integrity of fish communities in running water.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Index able to identify a variety of forms of degradation. Care must be taken to appropriately interpret results.
5. **Level of Education Needed to Perform Procedure:** Experience in the concept of the IBI and fish identification. Knowledge in the use of electrofishing techniques.
6. **Field Team Size:** Three
7. **Collection Time Required:** One hour per sample (three persons)
8. **Sample Processing Time:** One hour per sample (three persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 92

1. **Basic Reference:** Karr, J. R., R. C. Heidinger, E. H. Helmer. 1985. "Effects of Chlorine and Ammonia from Waste Water Treatment Facilities on Biotic Integrity", J. Water Pollut. Contr. Fed., 57:912-915.
2. **Procedure Objectives:** Determine if the IBI (Index of Biotic Integrity) is sensitive enough to track changes in biota of streams subjected to various concentrations of chlorine and ammonia.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** IBI was a good indicator of the effects of chlorine and ammonia from waste water.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 93

1. **Basic Reference:** Karr, J. R. 1981. "Assessment of Biotic Integrity Using Fish Communities", Fisheries, 6:21-27.
2. **Procedure Objectives:** An assessment system using a series of fish community attributes related to species contribution and ecological structure to evaluate the quality of an aquatic biota.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** IBI (Index of Biotic Integrity) reflects the status of fish communities and the environment supplying them.
5. **Level of Education Needed to Perform Procedure:** Experience in the concept of the IBI and fish identification. Knowledge in the use of electroshocking techniques.
6. **Field Team Size:** Three
7. **Collection Time Required:** One hour per sample (three persons)
8. **Sample Processing Time:** One hour per sample (three persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 94

1. **Basic Reference:** Karr, J. R. and D. R. Dudley. 1981. "Ecological Perspective on Water Quality Goals", Environmental Management, 5(1):55-68.
2. **Procedure Objectives:** Outline inadequacies of use of only physical chemical conditions to assess water quality and propose new approach.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** New approaches discussed in the use of aquatic life as well as traditional physical, chemical conditions to assess improvements.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 95

1. **Basic Reference:** Kathman, D. 1978. "Artificial Substrate Sampler for Benthic Invertebrates in Ponds, Small Lakes and Reservoirs", Prog. Fish Cult., 40:114-115.
2. **Procedure Objectives:** Description of artificial substrate for benthic macroinvertebrates.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Device prevents organisms from being dislodged and lost on retrieval due to bag enclosure.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 96

1. **Basic Reference:** Ketchum, B. H., Ed. 1983. "Ecosystems of the World. Volume 26: Estuaries and Enclosed Seas", Elsevier Scientific Publishing Co., 500 pp.
2. **Procedure Objectives:** Description of physical, chemical and biological characteristics of estuarine ecosystems of the world.
3. **Suitability for the Four Major Habitat Types**

Freshwater	x Marine	x Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Overview of estuarine ecosystems and enclosed seas with information on physical and biological aspects.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	x Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
x Phytoplankton	x Fish	

Reference Number – 97

1. **Basic Reference:** Keup, L. E. and C. S. Zabra. 1987. "Benthic Quality Standards", presentation at the 35th annual meeting, North American Benthological Society, Orono, Maine. 15 pp.
2. **Procedure Objectives:** Development of biological criteria for benthic macroinvertebrates to assess water quality and pollutant effects.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Numerical criteria for water quality determination.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 98

1. **Basic Reference:** Klopatek, J. M. 1988. "Some Thoughts on Using a Landscape Framework to Address Cumulative Impacts on Wetland Food Chain Support", Environmental Management, 12:703-711.
2. **Procedure Objectives:** Discussion of the problems of using food chain support as a functional attribute of a wetland.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Problems associated with using food chain support as a functional attribute of wetlands are discussed.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	x Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 99

1. **Basic Reference:** Kovalak, W. P. 1981. "Assessment and Prediction of Impacts of Effluents on Communities of Benthic Stream Macroinvertebrates", Ecological Assessments of Effluent Impacts on Communities of Indigenous Aquatic Organisms, ASTM STP 730, American Society for Testing and Materials, pp. 255-263.
2. **Procedure Objectives:** Determine species richness as a function of oxygen demand based on impact prediction model with the Shannon-Weaver and Brillouin indices.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Both indices have their short falls and should be used along with community analysis based on species richness and population densities.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure	x	Data Analysis
x Community Structure	x	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 100

1. Basic Reference: Krieger, K. A. 1984. "Benthic Macroinvertebrates as Indicators of Environmental Degradation in the Southern Nearshore Zone of the Central Basin of Lake Erie", J. Great Lakes Res., 10(2):197-209.
2. **Procedure Objectives:** Description of program to monitor macroinvertebrate populations to assess environmental degradation.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Program was able to sample a large area of Lake Erie.
5. **Level of Education Needed to Perform Procedure:** Knowledge of benthic macroinvertebrate sampling and identification.
6. **Field Team Size:** Two
7. **Collection Time Required:** 20 - 30 minutes per sample (two persons)
8. **Sample Processing Time:** One to two hours per sample (two prsons)
9. **Data Analysis Time:** Two to four hours (one person)

Subsection

Habitat Assessment		Population and Community Interaction
x Population Structure		Data Analysis
x Community Structure		Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 101

1. **Basic Reference:** Langdon, R. 1987. "Development of Fish Population Based Biocriteria in Vermont", EPA Region 5, Proceedings of National Workshop on Instream Biological Criteria, Lincolnwood, Illinois.
2. **Procedure Objectives:** Determine integrity of fish communities with the Index of Biotic Integrity (IBI) and Pinkham and Pearson's similarity coefficients.
3. **Suitability for the Four Major Habitat Types**

x	Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Found that the Vermont version of the IBI was sound with potential use in biocriteria, The PPCS (Pinkham and Pearson's similarity coefficient) had less potential.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton	Other Vertebrates
	Periphyton		Macroinvertebrates	
	Phytoplankton	x	Fish	

Reference Number – 102

1. **Basic Reference:** Larsen, D. P., J. M. Omernik, R. M. Hughes, C. M. Rohm, T. R. Whitter, A. J. Kinney, A. L. Gallant, D. R. Dudley. 1986. "Correspondence Between Spatial Patterns in Fish Assemblages in Ohio Streams and Aquatic Ecoregions", Environmental Management, 10:815-828.
2. **Procedure Objectives:** Determine correspondence of fish spatial patterns and patterns in the surrounding landscape.
3. **Suitability for the Four Major Habitat Types**

x	Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Four distinct ecoregions were classified in Ohio and found to be good indicators of fish distributions.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton	Other Vertebrates
	Periphyton		Macroinvertebrates	
	Phytoplankton	x	Fish	

Reference Number – 103

1. **Basic Reference:** Larson, E. W., D. L. Johnson and W. F. Lynch, Jr. 1986. "A Buoyant Pop Net for Accurately Sampling Fish at Artificial Habitat Structures", Trans. of the Amer. Fish. Soc., 115(2):351-355.
2. **Procedure Objectives:** Description and evaluation of a buoyant pop net for fish sampling.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Pop net was found to sample 100% of fish associated with artificial structure. Technique is labor intensive.
5. **Level of Education Needed to Perform Procedure:** Knowledge of fish usage of artifical structure, pop-net sampling and fish identification. SCUBA skills also necessary.
6. **Field Team Size:** Four or Five
7. **Collection Time Required:** One hour per sample (four persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** 30 - 60 minutes (one person)

Subsection

	Habitat Assessment	Population and Community Interaction
x	Population Structure	Data Analysis
x	Community Structure	Interpretive Assessment

Community Group

	Macrophytes	Zooplankton	Other Vertebrates
	Periphyton	Macroinvertebrates	
	Phytoplankton	x Fish	

Reference Number – 104

1. **Basic Reference:** Lauritsen, D. D., S. C. Mozley and D. S. White. 1985. "Distribution of Oligochaetes in Lake Michigan and Comments on Their Use as Indices of Pollution", J. Great Lakes Res., 11(1):67-76.
2. **Procedure Objectives:** Description of oligochaete distribution in Lake Michigan and their use as indices of pollution.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Benthic organisms considered good indicators of water quality.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment	Population and Community Interaction
x	Population Structure	Data Analysis
x	Community Structure	Interpretive Assessment

Community Group

	Macrophytes	Zooplankton	Other Vertebrates
	Periphyton	x Macroinvertebrates	
	Phytoplankton	Fish	

Reference Number – 105

1. **Basic Reference:** Leitch, W. G. 1966. "Historical and Ecological Factors in Wetland Inventory", Trans. N. Am. Wildl. Nat. Resour. Conf., 31:88-96.
2. **Procedure Objectives:** Discussion of the necessity of ecological and historical information in classification of wetlands.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Designed to help identify important wetlands for proper management.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 106

1. **Basic Reference:** Lenat, D. R. 1988. "Water Quality Assessment of Streams Using a Qualitative Collection Method for Benthic Macroinvertebrates", J. N. Am. Benthol. Soc., 7(3):222-223.
2. **Procedure Objectives:** Use of taxa richness criteria to assess water quality of streams based on multi-habitat collections of benthic macroinvertebrates with coarse and fine mesh samplers.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Multi-habitat collections reduce sample bias by collecting organisms from different available habitats. Slightly more labor intensive.
5. **Level of Education Needed to Perform Procedure:** Knowledge of sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** Two
7. **Collection Time Required:** One hour per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 107

1. **Basic Reference:** Lenat, D. R. 1984. "Agriculture and Stream Water Quality: A Biological Evaluation of Erosion Control Practices", Environmental Management, 8:333-334.
2. **Procedure Objectives:** Determine effects of agricultural runoff on the lower taxa richness of streams.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Benthic macroinvertebrates found to be good indicator of agricultural runoff effects. Effecting the EPT group the most.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 108

1. **Basic Reference:** Leonard, P. M. and D. J. Orth. 1986. "Application and Testing of an Index of Biotic Integrity (IBI) in Small, Coolwater Streams", Trans. Am. Fish. Soc., 115:401-414.
2. **Procedure Objectives:** Determine if the Index of Biotic Integrity is useful in evaluating fish community integrity in small, coolwater streams.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** A modified six metric IBI was found to be a good indicator of stream degradation.
5. **Level of Education Needed to Perform Procedure:** Knowledge of the IBI and fish sampling and identification.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 109

1. **Basic Reference:** Lucey, W. P., J. Desinger, A. Austin. 1986. "A Comparison of Algal Periphyton Communities Developed on Artificial Substrata in Two Dissimilar Containment Systems", Nat. Can., 113(2):153-164.
2. **Procedure Objectives:** Comparison of algal communities utilizing two artificial substrates - testing effectiveness of new substrate design.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Can be used to assess impacts where other devices are inappropriate.
5. **Level of Education Needed to Perform Procedure:** Knowledge of sampling and identification of periphyton with artifical substrates.
6. **Field Team Size:** Two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 2 - 3 hours per sample (one person)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
x	Periphyton		Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 110

1. **Basic Reference:** Lyons, J. 1988. "Correspondence Between the Distribution of Fish Assemblages in Wisconsin Streams and Proposed Aquatic Ecoregions", Am. Midland Nat. (in press).
2. **Procedure Objectives:** To determine usefulness of ecoregions classification in determining the distribution of fish assemblages.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Ecoregions can be used as a reference or baseline sites for comparison with potentially affected areas. Development of ecoregions takes time to develop.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 111

1. **Basic Reference:** Mahon, R. 1980. "Accuracy of Catch-effort Methods for Estimating Fish Density in Streams", Biol. Fish., 5(4):343-360.
2. **Procedure Objectives:** Determine accuracy of Leslie and DeLury estimates by electrofishing stream section and comparing to rotenone control.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Leslie and Rickes catch-effort methods were the least in error. Better estimates could be obtained by more effort but is more costly.
5. **Level of Education Needed to Perform Procedure:** Knowledge of fish sampling and identification. Knowledge of estimates for fish desities.
6. **Field Team Size:** Four to six
7. **Collection Time Required:** 8 hours for multiple sample estimate (six persons)
8. **Sample Processing Time:** 4 hours (six persons)
9. **Data Analysis Time:** 2 - 4 hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
	Community Structure	x	Interpretive Assessment

Community Group

x	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 112

1. **Basic Reference:** Maine Department of Environmental Protection. 1987. "Methods for Biological Sampling and Analysis of Maine's Waters", 18 pp.
2. **Procedure Objectives:** Use of rock filled baskets, artificial substrates, sieves, and nets to collect benthic macroinvertebrates.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Has the advantage of using both artificial substrate and natural substrate sampling methods to collect benthic macroinvertebrates.
5. **Level of Education Needed to Perform Procedure:** Knowledge of benthic macroinvertebrate sampling techniques and identification.
6. **Field Team Size:** Two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (one person)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

x	Habitat Assessment	x	Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 113

1. **Basic Reference:** Malvestuto, S. P. 1983. "Sampling the Recreation Fishery", in *Fisheries Techniques*, L. A. Nielsen and D. L. Johnson, Eds., American Fisheries Society, Bethesda, Maryland, pp. 397-420.
2. **Procedure Objectives:** Discussion of the collection of recreational fishery information using direct interview, on-site, survey sampling techniques.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Use of surveys to collect information about recreational fishery. Inexpensive and can collect a wide variety of information. Can have problems with survey biases.
5. **Level of Education Needed to Perform Procedure:** Knowledge of survey design.
6. **Field Team Size:** One
7. **Collection Time Required:** 4 - 6 hours per sample (one person)
8. **Sample Processing Time:** Two to four hours per sample (one person)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 114

1. **Basic Reference:** Masnik, M. T., J. R. Stauffer, Jr., and C. H. Hocutt. 1978. "A Comparison of Fish Collection Methods After Rotenone Application in New River Virginia", Virginia J. Sci., 29(1):5-9.
2. **Procedure Objectives:** Comparison of block net versus dip net of fish during rotenone application.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Block nets found to be a more effective method than hand dipping for collecting fish from rotenoning.
5. **Level of Education Needed to Perform Procedure:** Knowledge of fish toxicant sampling and fish identification.
6. **Field Team Size:** 5 - 10
7. **Collection Time Required:** 2 - 4 hours per sample (5 - 10 persons)
8. **Sample Processing Time:** 4 - 6 hours per sample (5 - 7 persons)
9. **Data Analysis Time:** 3 - 6 hours per sample (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 115

1. **Basic Reference:** Mason, W. T., Jr., C. I. Weber, P. A. Lewis, E. C. Julian. 1973. "Factors Affecting the Performance of Basket and Multi-Plate Macroinvertebrate Samplers", Freshwater Biology, 3:409-436.
2. **Procedure Objectives:** Factors affecting the performance of basket and multi-plate samplers, such as sampling depth and amount of exposure time were determined.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Depth and duration of colonization time affected the type and number of organisms collected with rock filled baskets.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 116

1. **Basic Reference:** Matthews, R. A., A. L. Buikema, Jr., J. Cairns, Jr. and J. H. Rodgers, Jr. 1982. "Biological Monitoring. Part IIA: Receiving System Functional Methods, Relationships and Indices", Water Research, 16:129-139.
2. **Procedure Objectives:** Examination of biological monitoring from a functional view, integrating structure and function into a more complete picture of ecosystem response to stress.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Functional information helps to give a clear understanding of ecosystem responses.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment	x	Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
x	Periphyton		Macroinvertebrates		
x	Phytoplankton		Fish		

Reference Number – 117

1. **Basic Reference:** Medine, A. J. and D. B. Porcella. 1982. "Eutrophication", J. Water Pollut. Control Fed., 54(6):770-778.
2. **Procedure Objectives:** Review of 116 publications on eutrophication.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
x Periphyton	Macroinvertebrates	
x Phytoplankton	Fish	

Reference Number – 118

1. **Basic Reference:** Melkic, A., E. Creese and D. Lewis. 1986. "Development of a Standard Clam Biomonitoring Methodology for the Detection of Trace Contaminants within Water of the Ontario Great Lakes Region", Technology Transfer Conference, Part B: Water Quality Research, pp. 205-218.
2. **Procedure Objectives:** Clam biomonitoring methodology for the detection of trace elements.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** The use of clams as a bioindicator for trace contaminants. Results are time integrated over whole exposure period but new source of uncontaminated clams need to be found.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 119

1. **Basic Reference:** Menge, B. A. and J. P. Sutherland. 1987. "Community Regulation : Variation in Disturbance, Competition and Predation in Relation to Environmental Stress and Recruitment", American Naturalist, 130:730-757.
2. **Procedure Objectives:** Describe predictions of a model of community regulation and the effects of variation in disturbance, competition, predation in relation to environmental stress and recruitment.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Use of modeling in assessing impacts of aquatic organisms.
5. **Level of Education Needed to Perform Procedure:** Knowledge of modeling and its use in aquatic systems.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure		Data Analysis
Community Structure	x	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 120

1. **Basic Reference:** Millar, J. B. 1976. "Wetland Classification in Western Canada: A Guide to Marshes and Shallow Open Water Wetlands in the Grasslands and Parks of the Prairie Provinces", Canadian Wildlife Service Report, Section 37, 38 pp.
2. **Procedure Objectives:** Description of classification system of marshes and shallow open waters.
3. **Suitability for the Four Major Habitat Types**

   Freshwater Marine Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** This classification technique categorizes wetlands with respect to vegetation parameters and will assist in wetland management.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment		Population and Community Interaction
Population Structure		Data Analysis
Community Structure	x	Interpretive Assessment

Community Group

x Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 121

1. **Basic Reference:** Millard, S. P. 1987. "Environmental Monitoring, Statistics and the Law: Room for Improvement", The American Statistician, 41:249-256.
2. **Procedure Objectives:** Alert the statistical community to deficiencies in the use of statistics in environmental monitoring.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marinex Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Stress the importance of integrating proper statistical procedures in environmental monitoring.
5. **Level of Education Needed to Perform Procedure:** Knowledge of statistical procedures and use for environmental monitoring.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 122

1. **Basic Reference:** Millard, S. P and D. P. Lettenmaier. 1986. "Optimal Design of Biological Sampling Programs Using the Analysis of Variance", Est. Coast. Shelf Sci., 22:637-656.
2. **Procedure Objectives:** Provides design considerations for establishing statistically sound studies.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 123

1. **Basic Reference:** Miller, D. L., P. M. Leonard, R. M. Hughes, J. R. Karr, P. B. Moyle, L. H. Schrader, B. A. Thompson, R. A. Daniels, K. D. Fausch, G. A. Fitzhugh, J. R. Gammon, D. B. Halliwell, P. L. Angermeier, and D. J. Orth. 1988. "Regional Applications of an Index of Biotic Integrity for Use in Water Resource Management", Fisheries, 13(5):12-20.
2. **Procedure Objectives:** Adapting the Index of Biotic Integrity (IBI) to different regions by changing metrics to accommodate regional differences in fish distribution and assemblage structure and function.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** IBI is a flexible index that can be adapted to conform to different regions.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 124

1. **Basic Reference:** Montanari, J. H. and J. E. Townsend. 1977. "Status of the National Wetlands Inventory", Trans. N. Am. Wildl. Resour. Conf., 42:66-72.
2. **Procedure Objectives:** Description of project to classify and map North American wetlands.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Overview of the status of the national wetlands inventory.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 125

1. **Basic Reference:** Morhadt, J. E. and E. Altouney. 1986. "Instream Flow Requirements Below Reservoirs: Conclusions from the EPRI Study", in *Lake and Reservoir Management - Vol. II.*, G. Redfield, J. Taggart and L. M. Moore, Eds., North American Lake Management Society, Washington, D. C., 458 pp.
2. **Procedure Objectives:** Reviews models for determining instream flows below reservoirs and biological effects of flow alteration.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 126

1. **Basic Reference:** Morris, J. 1987. "Evaluating the Wetland Resource", Environmental Management, 24:147-156.
2. **Procedure Objectives:** Review of possible methods for identifying and measuring costs, benefits and impacts of wetlands and agriculture systems.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Giving wetlands a monetary value as a way of measuring wetland worth.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 127

1. **Basic Reference:** Mukopadhyay, M. K., B. B. Ghosh, H. C. Joshi, M. M. Bagchi and H. C. Karmakar. 1987. "Biomonitoring of Pollution in the Hooghly Estuary by Using *Rita rita* as Test Fish, J. Env. Biol., 8(4):297-306.
2. **Procedure Objectives:** Observations of growth rate and deterioration of haematological condition to determine effects of estuary pollutants.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marinex	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Use of an indicator species for pollution monitoring. Some of the techniques for evaluation were laboratory intensive.
5. **Level of Education Needed to Perform Procedure:** Knowledge of fish sampling in estuaries and fish physiology.
6. **Field Team Size:** Two or three
7. **Collection Time Required:** Variable
8. **Sample Processing Time:** Variable
9. **Data Analysis Time:** Variable

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure		Data Analysis
	Community Structure		Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton		Macroinvertebrates		
	Phytoplankton	x	Fish		

Reference Number – 128

1. **Basic Reference:** Murphy, P. M. 1978. "The Temporal Variability in Biotic Indices", Environ. Pollut., 17:227-236.
2. **Procedure Objectives:** Determination of the seasonal stability of six biotic indices used in the assessment of water quality.
3. **Suitability for the Four Major Habitat Types**

x	Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Chandler Biotic Score and Average Chandler Biotic Score gave more consistant results than community based indices.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 129

1. **Basic Reference:** Newling, C. J. and H. K. Smith. 1982. "The Corps of Engineers Wetlands Research Program", Wetlands, 2:280-285.
2. **Procedure Objectives:** Description of program to develop methods of wetland delineation, techniques for determining wetland values and wetland restoration.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Provides professionals with a framework to help in wetland management.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction	
Population Structure	Data Analysis	
Community Structure	x Interpretive Assessment	

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 130

1. **Basic Reference:** Nielsen, L.A. and D. L. Johnson, Eds., 1983. *Fisheries Techniques.* American Fisheries Society, Bethesda, MD. 468 pp.
2. **Procedure Objectives:** A compendium of techniques for the analysis of fish populations and communities.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	x Marine	x Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	x Population and Community Interaction	
x Population Structure	x Data Analysis	
x Community Structure	Interpretive Assessment	

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 131

1. **Basic Reference:** Ohio E.P.A. 1987. "Biological Criteria for the Protection of Aquatic Life, Volume III. Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities", Ohio Environmental Protection Agency, Division of Water Quality Monitoring and Assessment, Surface Water Section, 55 pp.
2. **Procedure Objectives:** Quantitative and qualitative methods of sampling fish and macroinvertebrate populations with indices for relating community structure to water quality.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Uses both quantitative (Hester-Dendy) and qualitative techniques to assess benthic macroinvertebrates.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** Two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

x Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 132

1. **Basic Reference:** Omernik, J. M. 1987. "Ecoregions of the Conterminous United States", Annals of the Association of American Geographers, 77(1):118-125.
2. **Procedure Objectives:** Compilation of a map of the ecoregions of the conterminous U.S.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Development of a map of ecoregions for the United States.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 133

1. **Basic Reference:** Orlando, E. 1985. "Evaluation of Heavy Metals Sea Pollution by Marine Bioindicators", Oebalia, 11(1):93-100.
2. **Procedure Objectives:** Evaluation of heavy metal sea pollution.
3. **Suitability for the Four Major Habitat Types**

Freshwater	x Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Problems of an appropriate bioindicator and methods of sampling to monitor heavy metal pollution are discussed.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction	
x Population Structure	Data Analysis	
Community Structure	x Interpretive Assessment	

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 134

1. **Basic Reference:** Orth, D. J. 1983. "Aquatic Habitat Measurements", in *Fisheries Techniques*, L. A. Nielsen and D. L. Johnson, Eds., American Fisheries Society, Bethesda, Maryland. pp. 61-84.
2. **Procedure Objectives:** Discussion of sources of information, techniques, equipment and biases relating to aquatic habitat assessment.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Overview of habitat measurements for lakes and streams/rivers.
5. **Level of Education Needed to Perform Procedure:** Knowledge of habitat measurement techniques for aquatic habitats.
6. **Field Team Size:** Variable
7. **Collection Time Required:** Variable
8. **Sample Processing Time:** Variable
9. **Data Analysis Time:** Variable

Subsection

x Habitat Assessment	Population and Community Interaction	
Population Structure	Data Analysis	
Community Structure	Interpretive Assessment	

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 135

1. **Basic Reference:** Pascoe, D. and R. W. Edwards (Eds.). 1985. "Compliance Biomonitoring Standard Development and Regulation Enforcement Using Biomonitoring Data", Freshwater Biological Monitoring: Proceedings of a Specialized conference held in Cardiff, U.K., 12-14 September, 1984., Adv. Water Pollut. Control.
2. **Procedure Objectives:** Review requirements for implementation of compliance biomonitoring and evaluates several methods of data collection and analysis.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Emphasizes the importance of stringent collection and analysis of data to be statistically reliable and have interpretative strength.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure		Data Analysis
Community Structure	x	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 136

1. **Basic Reference:** Paul, J. F., A. F. Holland, K. J. Scott, D. A. Flemer and E. P. Meier. 1989. "An Ecological Status and Trends Program: EPA's Approach to Monitoring the Condition of the Nation's Ecosystems", Presentation at Oceans '89, September 18-21, Seattle, WA.
2. **Procedure Objectives:** Description of EPA's environmental monitoring and assessment program to monitor the nation's ecosystems.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Environmental Monitoring and Assessment Program (EMAP) will help to monitor coastal waters, forests, freshwater wetlands, surface waters and agroecosystems.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment		Population and Community Interaction
Population Structure		Data Analysis
Community Structure		Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 137

1. **Basic Reference:** Peckarshy, B. L. 1986. "Colonization of Natural Substrates by Stream Benthos", Can. J. Fish. Aquat. Sci., 43:700-709.
2. **Procedure Objectives:** Comparison of benthos communities colonizing artificial substrates between seasonal and temporal (nonseasonal) succession.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Temporal succession was observed on artificial substrate but the importance of biological interactions in determining these changes are unclear.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 138

1. **Basic Reference:** Pinder, L. C. V., M. Ladle, T. Gledholl, J. A. B. Bass and A. M. Matthews. 1987. "Biological Surveillance of Water Quality. 1. A Comparison of Macroinvertebrate Surveillance Methods in Relation to Assessment of Water Quality in a Chalk Stream", Arch. Hydrobiol., 109(2):207-226.
2. **Procedure Objectives:** Comparison of macroinvertebrates obtained from various types of sediments with diversity and pollution indices to determine optimum surveillance method.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** A comparison of different sampling methods and analysis techniques are discussed for benthic macroinvertebrates.
5. **Level of Education Needed to Perform Procedure:** Knowledge of sampling techniques for benthic macroinvertebrates.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 139

1. **Basic Reference:** Pratt, J. M., R. A. Color and P. J. Godfrey. 1981. "Ecological Effects of Urban Stormwater Runoff on Benthic Macroinvertebrates Inhabiting the Green River, Massachusetts", Hydrobiologia, 83:29-42.
2. **Procedure Objectives:** Use of benthic macroinvertebrates to assess urban runoff in a river system.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Four analytical procedures identified effects of urban stormwater runoff on benthic macroinvertebrates.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 140

1. **Basic Reference:** Preston, E. M. and B. L. Bedford. 1988. "Evaluating Cumulative Effects on Wetland Functions: A Conceptual Overview and Generic Framework", Environmental Management, 12:565-583.
2. **Procedure Objectives:** Provide a generic framework for evaluating cumulative effects on three basic wetland landscape functions: flood storage, water quality and life support.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Foundation for further study to quantify cumulative effects of wetland loss or degradation on the functioning of interacting wetland systems.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 141

1. **Basic Reference:** Pryfogle, P. A. and R. L. Lowe. 1979. "Sampling and Interpretation of Epilithic Diatom Communities", in *Methods and Measurements of Periphyton Communities: A Review*, ASTM STP 690, R. L. Weitzel, Ed., American Society for Testing and Materials, pp. 77-89.
2. **Procedure Objectives:** Analysis of diatoms from quantitative samples for density and species diversity and affects of including dead cells.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Inclusion of dead diatom cells in analysis-increased standing crop and diversity.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
x Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 142

1. **Basic Reference:** Rabeni, C. F. and K. F. Gibbs. 1988. "Ordination of Deep River Invertebrate Communities in Relation to Environmental Variables", Hydrobiologia, 74:67-76.
2. **Procedure Objectives:** Use of artificial structure and divers to assess environmental changes on a deep river system.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** A method for collecting a quantitative benthic macroinvertebrate sample from large rivers. Labor intensive.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates. Skill in Scuba diving.
6. **Field Team Size:** Three
7. **Collection Time Required:** 20 - 30 minutes per sample (three persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 143

1. **Basic Reference:** Rabeni, C. F. and K. E. Gibbs. 1978. "Comparison of Two Methods Used by Divers for Sampling Benthic Invertebrates in Deep Rivers", J. Fish Res. Bd. Can., 35:332-336.
2. **Procedure Objectives:** Comparison between basket and Hess samplers for collecting aquatic macroinvertebrates.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Both Hess sampler and rock-basket found to be efficient samplers in deep rivers.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and idetification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 144

1. **Basic Reference:** Resh, V. H. 1988. "Variability, Accuracy, and Taxonomic Costs of Rapid Assessment Approaches in Benthic Biomonitoring", Draft, Presented at the 1988 N. Amer. Benthological Soc. Tech. Info. Workshop, Tuscaloosa, AL.
2. **Procedure Objectives:** Discusses implications of rapid bioassessment approaches for benthic communities.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 145

1. **Basic Reference:** Resh, V. H. and J. D. Unzickes. 1975. "Water Quality Monitoring and Aquatic Organisms: The Importance of Species Identification", Water Quality Monitoring, 47:9-17.
2. **Procedure Objectives:** To point out the importance of species level identification of benthic macroinvertebrates for biological monitoring.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Need species level identification but need to appropriate keys for effective biomonitoring. Species level identification takes more time.
5. **Level of Education Needed to Perform Procedure:** Knowledge of benthic macroinvertebrate identification.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 146

1. **Basic Reference:** Reynolds, J. B. 1983. "Electrofishing", in *Fisheries Techniques*, L. A. Nielson and D. L. Johnson Eds., American Fisheries Society, Bethesda, Maryland.
2. **Procedure Objectives:** Use of electricity to capture fish.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Advantage - good sample with minimal time and effort. Disadvantage - can be dangerous, biased.
5. **Level of Education Needed to Perform Procedure:** Knowledge of electrofishing techniques, fish behavior and fish identification.
6. **Field Team Size:** Variable
7. **Collection Time Required:** Variable
8. **Sample Processing Time:** Variable
9. **Data Analysis Time:** Variable

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 147

1. **Basic Reference:** Richkus, W. A. 1980. "Problems in Monitoring Marine and Estuarine Fishes", in *Biological Monitoring of Fish*, Hocutt, O. H. and J. Stauffer, Jr., Eds., D. C. Heath and Co., pp. 83-118.
2. **Procedure Objectives:** Describe problems in sampling strategy and data analysis of marine and estuarine fishes.
3. **Suitability for the Four Major Habitat Types**

Freshwater	x Marine	x Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Explains advantages and disadvantages of biomonitoring of fish in marine and estuarine systems.
5. **Level of Education Needed to Perform Procedure:** Knowledge of various sampling techniques and fish behavior in marine and estuary systems.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 148

1. **Basic Reference:** Roby, K. B., J. D. Newbold and D. C. Erman. 1978. "Effectiveness of an Artificial Substrate for Sampling Macroinvertebrates in Small Streams", Freshwater Biology, 8:1-8.
2. **Procedure Objectives:** Effectiveness of small porcelain balls as an artificial substrate for collecting macroinvertebrates in small streams.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Artificial substrate sampler (porcelain balls) was found to be undependable in the collection of benthic macroinvertebrates.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 149

1. **Basic Reference:** Rodgers, J. H. Jr., K. L. Dickson, J. Cairns, Jr. 1979. "A Review and Analysis of Some Methods Used to Measure Functional Aspects of Periphyton", in *Methods and Measurements of Periphyton Communities: A Review*, ASTM STP 690, R. L. Weitzel, Ed., American Society for Testing and Materials, pp. 142-167.
2. **Procedure Objectives:** Analysis of methods used to measure the functional aspects of periphyton.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Seasonal periphyton did not indicate changes in structure of function in treated streams.
5. **Level of Education Needed to Perform Procedure:** Knowledge of periphyton sampling, structure and funtion.
6. **Field Team Size:** Variable
7. **Collection Time Required:** Variable
8. **Sample Processing Time:** Variable
9. **Data Analysis Time:** Variable

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
x Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 150

1. **Basic Reference:** Roline, R. A. and J. J. Sartoris. 1988. "Changes in the Morphometry of Las Vegas Wash and the Impact on Water Quality", Lake and Reservoir Management, 4(1):135-142.
2. **Procedure Objectives:** Changes in physical/chemical parameters due to changes in morphometry of the wash entering Las Vegas wetland.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Need to use macrophytes in trophic classification. Trophic status needs to be used with discretion when implementing restoration. A eutrophic lake with high TSI (trophic status indices) does not mean poorer quality in all situations.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

x Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 151

1. **Basic Reference:** Rosas, I., M. Mazari, J. Saavedra and A. P. Baez. 1985. "Benthic Organisms as Indicators of Water Quality in Lake Patzcuaro, Mexico", Water, Air, Soil Pollution, 25:401-414.
2. **Procedure Objectives:** Use of benthic macroinvertebrates to assess water quality in a Mexican lake.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Benthic organisms were good indicators of both industrial and domestic waste.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 152

1. **Basic Reference:** Rosenberg, D. M., H. V. Danks, D. M. Lehmkul. 1986. "Importance of Insects in Environmental Impact Assessment", Environmental Management, 10:773-783.
2. **Procedure Objectives:** Describe usefulness of insects in environmental impact assessment.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	x Marine	x Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Insects are good for environmental assessment because they are diverse, ubiquitous in occurrence, and important in the functioning of natural ecosystems. Species level identification is emphasized.
5. **Level of Education Needed to Perform Procedure:** Knowledge of insect collection and identication.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 153

1. **Basic Reference:** Rosenburg, D. M. and V. H. Resh. 1982. "The Use of Artificial Substrates in the Study of Freshwater Benthic Macroinvertebrates", in *Artificial Substrates*, J. Cairns, Jr. Ed., Ann Arbor Science, Ann Arbor, Michigan.
2. **Procedure Objectives:** Assess advantages and disadvantages in the use of artificial substrates and elucidate the general principles governing the dynamics of colonization.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Advantages: standardization of microhabitat, flexible, precise. Disadvantage: seasonal variation, long exposure requirement.
5. **Level of Education Needed to Perform Procedure:** Knowledge of the use of artificial substrates and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 154

1. **Basic Reference:** Ruth, P. 1973. "Use of Algae, Especially Diatoms, in the Assessment of Water Quality", in *Biological Methods for the Assessment of Water Quality*, ASTM STP 528, J. Cairns, Jr., K. L. Dickson, Eds., American Society for Testing and Materials, pp. 76-95.
2. **Procedure Objectives:** Observation and analysis of natural and laboratory cultures of algae (diatoms) on artificial substrates for pollution impacts.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Advantages and disadvantages of single species versus natural community structure are discussed.
5. **Level of Education Needed to Perform Procedure:** Knowledge of sampling and identification of diatoms using artificial substrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
x Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 155

1. **Basic Reference:** Saila, S. B., R. A. Pikanowski and D. S. Vaughan, 1976. Estuarine and Coastal Marine Science, Vol. 4., pp. 119-128.
2. **Procedure Objectives:** Discusses sampling design considerations for estuarine field programs.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	x Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure	x	Data Analysis
Community Structure		Interpretive Assessment

Community Group

Macrophytes		Zooplankton	Other Vertebrates
Periphyton	x	Macroinvertebrates	
Phytoplankton	x	Fish	

Reference Number – 156

1. **Basic Reference:** Schaeffer, D. J., W. H. Ettinger, W. J. Tucker and H. W. Kerster. 1985. "Evaluation of a Community-Based Index Using Benthic Indicator Organisms for Classifying Stream Quality", J. Water Pollut. Contr. Fed., 57:167-171.
2. **Procedure Objectives:** Determine whether benthic classification of stream quality accurately represents the chemical classification of stream quality.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Benthic classification to determine stream quality is discussed.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure	x	Data Analysis
x Community Structure	x	Interpretive Assessment

Community Group

Macrophytes		Zooplankton	Other Vertebrates
Periphyton	x	Macroinvertebrates	
Phytoplankton		Fish	

Reference Number – 157

1. **Basic Reference:** Shackleford, B. 1988. "Rapid Bioassessment of Lotic Macroinvertebrate Communities: Biocriteria Development", State of Arkansas, Department of Pollution Control and Ecology, 45 pp.
2. **Procedure Objectives:** Use of benthic macroinvertebrates to assess water quality in flowing waters.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Accurate cost-effective tool way of assessing water quality.
5. **Level of Education Needed to Perform Procedure:** Knowledge of benthic macroinvertebrate sampling and identification.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

x Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 158

1. **Basic Reference:** Shannon C. E. and W. Weaver. 1949. "The Mathematical Theory of Communication", The Univ. of Illinois Press, Urbana, IL., pp. 19-27, 82-83, 104-107.
2. **Procedure Objectives:** Discusses the use of information theory in evaluating diversity.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 159

1. **Basic Reference:** Sheldon, A. L. 1984. "Cost and Precision in a Stream Sampling Program", Hydrobiologia, 111:147-152.
2. **Procedure Objectives:** Discusses options concerning resource expenditures and data precision.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:**
5. **Level of Education Needed to Perform Procedure:**
6. **Field Team Size:**
7. **Collection Time Required:**
8. **Sample Processing Time:**
9. **Data Analysis Time:**

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 160

1. **Basic Reference:** Siegfried, C. A. 1988. "Planktonic Indicators of Lake Acidification in the Adirondack Mountain Region of New York State", Lake and Reservoir Management, 4(1):115-121.
2. **Procedure Objectives:** Relationship between lake acidity and plankton community structure using species richness.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Use of biomass of certain plankton groups are good indicators of acidification problems.
5. **Level of Education Needed to Perform Procedure:** Knowledge of plankton sampling and identification.
6. **Field Team Size:** Two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** Two to four hours per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	x Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
x Phytoplankton	Fish	

Reference Number – 161

1. **Basic Reference:** Siegfried, C. A., J. A. Bloomfield and J. W. Sutherland. 1987. "Acidification, Vertebrate and Invertebrate Predators and the Structure of Zooplankton Communities in Adirondack Lakes", Lake and Reservoir Management, 3:385-393.
2. **Procedure Objectives:** The interaction of acidity status and vertebrate plaktivore abundance relating to zooplankton grazer community variation.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Lowest level of trophic community which effects whole system. Not a high profile organism in publics mind.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	x Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 162

1. **Basic Reference:** Steedman, R. J. 1988. "Modification and Assessment of an Index of Biotic Integrity to Quantify Stream Quality in Southern Ontario", Canadian Journal of Fisheries and Aquatic Science, 45:492-501.
2. **Procedure Objectives:** Adaptation of IBI to conditions in Canada.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Good indicator of stream quality from land use disturbances.
5. **Level of Education Needed to Perform Procedure:** Knowledge of electrofishing and fish identification. Knowledge of the use of the IBI (Index of Biotic Integrity).
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 163

1. **Basic Reference:** Steinhart, C. E., L. J. Schierow and W. C. Sonzogni. 1982. "Environmental Quality Index for the Great Lakes", Water Resources Bulletin, 18(6):1025-1031.
2. **Procedure Objectives:** Describes new index for summarizing water quality for nearshore waters of the Great Lakes, based on physical, chemical, biological and toxic substance variables.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Index combines many variables to assess water quality but this can be expensive.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x	Habitat Assessment	Population and Community Interaction
	Population Structure	x Data Analysis
x	Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 164

1. **Basic Reference:** Strange, R. J. 1983. "Field Examination of Fish", in *Fisheries Techniques*, L. A. Nielsen and D. L. Johnson, Eds., American Fisheries Society, Bethesda, Maryland, pp. 337-348.
2. **Procedure Objectives:** Discussion of techniques and limitations in the field examination of fish.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Procedures discussed in assessing fish health and illness by field examination. Need to be trained to assess fish health.
5. **Level of Education Needed to Perform Procedure:** Knowledge of fish health and diseases.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction	
Population Structure	Data Analysis	
Community Structure	x Interpretive Assessment	

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 165

1. **Basic Reference:** Sullivan, J. H., H. D. Putnam, J. T. McClave and D. R. Swift. 1981. "Statistical Techniques for Evaluating Procedures and Results for Periphyton Sampling", in *Ecological Assessments of Effluent Impacts on Communities of Indigenous Aquatic Organisms*, ASTM STP 730, J. M. Bates and C. I. Weber, Eds., American society for Testing and Materials, pp. 132-141.
2. **Procedure Objectives:** The evaluation of density, diversity and dominant organisms on glass slides incubated at various locations in a reservoir receiving industrial effluent.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Evaluation of sampling techniques for periphyton are discussed along with statistical procedures.
5. **Level of Education Needed to Perform Procedure:** Knowledge of sampling and identification of periphyton.
6. **Field Team Size:** Two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** Two to four hours per sample (one person)
9. **Data Analysis Time:** Two to three hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
x Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 166

1. **Basic Reference:** Szczytyko, S. W. 1988. "Investigation of New Interpretive Techniques for Assessing Biomonitoring Data and Stream Water Quality in Wisconsin Streams", Report to the Surface Water Monitoring Committee, Wisconsin Department of Natural Resources, 85 pp.
2. **Procedure Objectives:** Investigate the utility of using new techniques (similarity indices, diversity indices, species and generic richness, dominate species, Ephemeroptera - Plecoptera - Tricoptera index) to supplement Hilsenhoff biotic index data.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** HBI keys on arthropods which are a good indicator of intermittent or mild organic enrichment. Index is limited to detection of organic enrichment.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 167

1. **Basic Reference:** Tesmer, M. G. and D. R. Wefring. 1981. "Annual Macroinvertebrate Sampling - A Low Cost Tool for Ecological Assessment of Effluent Impact", in *Ecological Assessment of Effluent Impacts on Communities of Indigenous Aquatic Organisms*, ASTM STP 730, J.M. Bates and C.I. Weber, Eds., American Society for Testing and Materials, pp. 214-279.
2. **Procedure Objectives:** Annual sampling of macroinvertebrates to assess impacts of effluent discharge on rivers.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Annual sampling of macroinvertebrates was able to distinguish between natural fluctuations and fluctuations due to effluent discharge.
5. **Level of Education Needed to Perform Procedure:** Knowledge of sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 168

1. **Basic Reference:** Tiner, R. W., Jr. 1984. "Wetlands of the United States: Current Status and Recent Trends", U.S. EPA, U.S. Government Printing Office, Washington, D. C., 57 pp.
2. **Procedure Objectives:** Describe current status and historical trends of U.S. Wetlands.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Overview of the importance of wetlands for wildlife as well as water quality and economic issues.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	x Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 169

1. **Basic Reference:** Tsui, P. T. P. and B. W. Breedlove. 1978. "Use of the Multi-Plate Sampler in Biological Monitoring of the Aquatic Environment", Florida Scientist, 4(2):110-116.
2. **Procedure Objectives:** Determine effectiveness of multi-plate sampler to collect aquatic macroinvertebrates and compare results with data from Ponar grab to determine most efficient collector.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Differences in exposure time of artificial substrates and comparisons between artificial substrates and Ponar grabs are discussed for both lotic and lentic systems.
5. **Level of Education Needed to Perform Procedure:** Knowledge of sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 170

1. **Basic Reference:** U. S. Environmental Protection Agency. 1986-1990. "Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound", Puget Sound Estuary Program, U. S. EPA, Region 10, Office of Puget Sound, Seattle, WA.
2. **Procedure Objectives:** A compendium of procedures for environmental monitoring of estuarine waters. Includes biological and toxicity test methods.
3. **Suitability for the Four Major Habitat Types**

   Freshwater Marine x Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 171

1. **Basic Reference:** U. S. Environmental Protection Agency. 1990. "Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters", D. J. Klemm, P. A. Lewis and J. M. Lazorchak (Authors), Draft Report No. EPA/600/0-90/000, U. S. EPA, Environmental Monitoring Systems Laboratory, Office of Modeling, Monitoring Systems, and Quality Assurance, Office of Research and Development, Cincinnati, OH., 236 pp.
2. **Procedure Objectives:** Describes guidelines and standardized procedures for using benthic invertebrates (macroinvertebrates) in evaluating the biological integrity of surface waters.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:**
5. **Level of Education Needed to Perform Procedure:**
6. **Field Team Size:**
7. **Collection Time Required:**
8. **Sample Processing Time:**
9. **Data Analysis Time:**

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure	x	Data Analysis
Community Structure	x	Interpretive Assessment

Community Group

Macrophytes		Zooplankton	Other Vertebrates
Periphyton	x	Macroinvertebrates	
Phytoplankton		Fish	

Reference Number – 172

1. **Basic Reference:** U. S. Environmental Protection Agency. 1990. "Biological Criteria National Program Guidance for Surface Waters", Report No. EPA-440/5-90-004, U. S. EPA, Office of Water Regulation and Standards, Washington, D.C. 57 pp.
2. **Procedure Objectives:** Presents general program guidance for the development of biological criteria.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marinex Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** NA
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 173

1. **Basic Reference:** U. S. Environmental Protection Agency. 1988. "Proceedings of the First National Workshop on biological Criteria", Lincolnwood, Illinois, December 2-4, 1987. Report No. 905/9-89/003, U.S. EPA, Chicago, Illinois.
2. **Procedure Objectives:** Workshop was designed to consolidate ideas from professionals on the concept of biological monitoring.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Consolidated information on biological monitoring so that other professionals could benefit.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 174

1. **Basic Reference:** U. S. Environmental Protection Agency. 1987. "Surface Water Monitoring: A Framework for Change", Office of Water, Office of Policy Planning and Evaluation, U.S. EPA, Washington, D.C. 41 pp.
2. **Procedure Objectives:** To determine where EPA's surface water monitoring program should be in the late 1980s to ensure that it can meet the information needs of water quality managers in the 19990's, and to identify where and how adjustments to the program should be made.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** This document would streamline procedures for water monitoring.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 175

1. **Basic Reference:** U. S. Environmental Protection Agency. 1985. "Technical Support Document for Water Quality-Based Toxics Control", Report No. 440/4-85/03, Office of Water, U. S. EPA, Washington, D.C.
2. **Procedure Objectives:** Provides procedural recommendations for identifying, analyzing and controlling adverse water quality impacts.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Treatment systems are more easily designed to meet chemical requirements. All toxicants in complex wastewater may not be known making requirements difficult.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment		Population and Community Interaction
Population Structure		Data Analysis
Community Structure	x	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 176

1. **Basic Reference:** U. S. Environmental Protection Agency. 1984. "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring", Report No. OWRS QA-1, U. S. EPA, Washington, D.C.
2. **Procedure Objectives:** Work quality assurance project plans ensure quality of environmental monitoring.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Ensure quality in environmental monitoring.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 177

1. **Basic Reference:** U. S. Environmental Protection Agency. 1984. "The Development of Data Quality Objectives", prepared by the EPA Quality Assurance Management staff and the DQO workgroup, U. S. EPA, Washington, D.C.
2. **Procedure Objectives:** Data quality objectives ensure the quality of the data to strengthen results.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Ensures the quality of the data collected.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 178

1. **Basic Reference:** U. S. Environmental Protection Agency. 1984. "Policy and Program Requirement to Implement the Quality Assurance Program", EPA order 5360.1, U. S. EPA, Washington, D.C.
2. **Procedure Objectives:** Quality assurance programs used to ensure the quality of programs.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Ensures the quality of programs.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 179

1. **Basic Reference:** U. S. Environmental Protection Agency. 1984. Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analyses, Volume III: Lake Systems. U. S. EPA, Office of Water Regulations and Standards, Washington, D. C.
2. **Procedure Objectives:** Guidance prepared by EPA to assist states in implementing the revised water quality standards regulation.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Procedures for surveys of lake systems.
5. **Level of Education Needed to Perform Procedure:** Knowledge of lake systems with emphasis on habitat and biological assessment.
6. **Field Team Size:** Varies
7. **Collection Time Required:** Varies
8. **Sample Processing Time:** Varies
9. **Data Analysis Time:** Varies

Subsection

x Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	Interpretive Assessment

Community Group

x Macrophytes	x Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
x Phytoplankton	x Fish	

Reference Number – 180

1. **Basic Reference:** U. S. Environmental Protection Agency. 1983. "Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analyses", [Volume I. Rivers and Streams]. U. S. EPA, Office of Water Regulations and Standards, Washington, D.C.
2. **Procedure Objectives:** Guidelines for use attainability of a waterbody.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Gives technical guidance to professionals to analyze data to ascertain use attainability.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 181

1. **Basic Reference:** U. S. Environmental Protection Agency. 1983. "Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analyses", Volume II. Estuarine Systems. U. S. EPA., Office of Water Regulations and Standards, Washington, D.C., 227 pp.
2. **Procedure Objectives:** General information about physical, chemical and biological characteristics of aquatic habitat for water quality assessment.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Procedures for surveys of waterbodies to determine use attainability.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both benthic and fish sampling and identification.
6. **Field Team Size:** Varies
7. **Collection Time Required:** Varies
8. **Sample Processing Time:** Varies
9. **Data Analysis Time:** Varies

Subsection

x Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 182

1. **Basic Reference:** U. S. Environmental Protection Agency. 1983. Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analysis. Volume II: Estuarine systems. U. S. EPA, Washington, D.C. 186 pp.
2. **Procedure Objectives:** Description of the major physical, chemical and biological attributes of estuaries.
3. **Suitability for the Four Major Habitat Types**

   Freshwater Marinex Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Procedures for assessing use attainability for estuarine systems.
5. **Level of Education Needed to Perform Procedure:** Knowledge of estuaries with emphasis on habitat and biological attributes.
6. **Field Team Size:** Varies
7. **Collection Time Required:** Varies
8. **Sample Processing Time:** Varies
9. **Data Analysis Time:** Varies

Subsection

x Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	x Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
x Phytoplankton	x Fish	

Reference Number – 183

1. **Basic Reference:** U. S. Environmental Protection Agency. 1980. "Intern Guidelines and Specifications for Preparing Quality Assurance Project Plans", Report No. QAMS-005180, U. S. EPA, Washington, D.C.
2. **Procedure Objectives:** Quality assurance project plans help to ensure the quality of projects.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Ensures the quality of projects.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 184

1. **Basic Reference:** U. S. Environmental Protection Agency. 1980. "Guidelines and Specifications for Preparing Quality Assurance Program Plans", Report No. QAMS-004180, U. S. EPA, Washington, D.C.
2. **Procedure Objectives:** Quality assurance program plans help to ensure the quality of programs.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Ensure the quality of programs.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 185

1. **Basic Reference:** U. S. Environmental Protection Agency. 1973. "Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents", C. I. Weber, Ed., EPA-670/4-73-001, U. S. EPA, Office of Research and Development, Cincinnati, OH.
2. **Procedure Objectives:** Selection of methods for use in routine field and laboratory work in fresh and marine waters arising during short-term enforcement studies, water quality trend monitoring, effluent testing and research projects.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Selection of methods for various types of work.
5. **Level of Education Needed to Perform Procedure:**
6. **Field Team Size:**
7. **Collection Time Required:**
8. **Sample Processing Time:**
9. **Data Analysis Time:**

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	x Zooplankton	Other Vertebrates
x Periphyton	x Macroinvertebrates	
x Phytoplankton	x Fish	

Reference Number – 186

1. **Basic Reference:** Van Dyk, L. P., C. G. Greeff and J. J. Brink. 1975. "Total Population Density of Crustacea and Aquatic Insecta as an Indicator of Fenthion Pollution of River Water", Bull. Environ. Contam. Toxicol., 14:426-431.
2. **Procedure Objectives:** Description of a monitoring program involving macroinvertebrates and residue analysis of water.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:**
5. **Level of Education Needed to Perform Procedure:**
6. **Field Team Size:**
7. **Collection Time Required:**
8. **Sample Processing Time:**
9. **Data Analysis Time:**

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 187

1. **Basic Reference:** Van Horn, W. M. 1950. "The Biological Indices of Stream Quality", Proc. 5th Ind. Waste Conf., Purdue Univ. Est. Ser., 72:215.
2. **Procedure Objectives:** Provides numeric indices for biological stream data.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Of historic value but outdated.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction	
x Population Structure	x Data Analysis	
x Community Structure	Interpretive Assessment	

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 188

1. **Basic Reference:** Verma, S. R. and I. R. Tonk. 1984. "Biomonitoring of the Contamination of Water by a Sublethal Concentration of Pesticides, A System Analysis Approach", ACTA Hydrochem. Hydrobiol., 12:399-409.
2. **Procedure Objectives:** Observation of sublethal effects of several biocides on fish respiration and enzyme activity.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Detailed information on fish physiology with respect to pesticide contamination. Technology and time intensive.
5. **Level of Education Needed to Perform Procedure:** Extensive knowledge of fish physiology and fish biomonitoring systems.
6. **Field Team Size:** One or two
7. **Collection Time Required:** Automated
8. **Sample Processing Time:** Automated
9. **Data Analysis Time:** Two to six hours

Subsection

Habitat Assessment	Population and Community Interaction	
x Population Structure	Data Analysis	
Community Structure	Interpretive Assessment	

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 189

1. **Basic Reference:** Vermont Agency of Natural Resources. 1988. "Biological Compliance Monitoring Methods Manual", Department of Environmental Conservation, 72 pp.
2. **Procedure Objectives:** Sampling and analytical procedures to assess effects of indirect discharges on high quality running waters (bases on macroinvertebrates populations using rock filled baskets).
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Use rock filled basket to sample benthic macroinvertebrates because best suited for Vermont streams and rivers. Quantitative sample.
5. **Level of Education Needed to Perform Procedure:** Knowledge of benthic macroinvertebrate sampling and identification.
6. **Field Team Size:** Two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

x Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 190

1. **Basic Reference:** Vincent, R. 1971. "River Electrofishing and Fish Population Estimates", Progressive Fish Culturist, 33(3):163-167.
2. **Procedure Objectives:** Use of electrofishing to make estimates of fish populations in rivers.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Effective method for collecting fish from rivers for biomonitoring. Can be moderately labor and time intensive.
5. **Level of Education Needed to Perform Procedure:** Experience in electrofishing and safety procedures. Experience in taxonomy and sample design and analysis.
6. **Field Team Size:** Three
7. **Collection Time Required:** One hour per station (three persons)
8. **Sample Processing Time:** Two hours per station (three persons)
9. **Data Analysis Time:** 10 - 15 hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 191

1. **Basic Reference:** Voshell, J. R., Jr. and G. M. Simmons, Jr. 1977. "An Evaluation of Artificial Substrates for Sampling Macrobenthos in Reservoirs", Hydrobiologia, 53:257-269.
2. **Procedure Objectives:** Comparison of artificial substrates with Ponar grab for sampling benthic macroinvertebrates in lakes to find which technique was best for assessing thermal effluent effects.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Artificial substrates collected more individuals and taxa than ponar grab. Incubation period (4 weeks) needed for artificial substrate.
5. **Level of Education Needed to Perform Procedure:** Knowledge of sampling and identification of benthic macroinvertebrates using artificial substrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 192

1. **Basic Reference:** Waldichuk, M. and C. S. Hegre. 1973. "Trends in Methodology for Evaluation of Effects of Pollutants on Marine Organisms and Ecosystems", in *CRC Critical Reviews in Environmental Control*, 3:167-210.
2. **Procedure Objectives:** Review of methodology for evaluation of effects of pollutants on marine organisms.
3. **Suitability for the Four Major Habitat Types**

   Freshwater x Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Overview of the changes in methodology for assessing the effect of pollutants on marine organisms and ecosystems.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

	Habitat Assessment		Population and Community Interaction
x	Population Structure	x	Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes	x	Zooplankton		Other Vertebrates
	Periphyton	x	Macroinvertebrates		
x	Phytoplankton	x	Fish		

Reference Number – 193

1. **Basic Reference:** Walker, W. W. Jr. "Statistical Bases for Mean Chlorophyll a Criteria", Water Quality Cirteria and Standards, Lake and Reservoir Managament, pp.57-62.
2. **Procedure Objectives:** Use of indices relating chlorophyll a values to use impairment of lakes - development of criteria for lake protection standards.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Use of chlorophyll a to predict extreme conditions such a maximum chlorophyll a or nuisance bloom frequency.
5. **Level of Education Needed to Perform Procedure:** Knowledge of periphyton sampling and chlorophyll a analysis.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** One to two hours per sample (one person)
9. **Data Analysis Time:** One to two hours per sample

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
x Periphyton	Macroinvertebrates	
x Phytoplankton	Fish	

Reference Number – 194

1. **Basic Reference:** Washington, H. G. 1984. "Diversity, Biotic and Similarity Indices: A Review with Special Relevance to Aquatic Ecosystems", Water Res., 18:653-694.
2. **Procedure Objectives:** Evaluation of several indices listing where they are best applied, advantages and limitations.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Should narrow down list of indices to only those biologically relevant.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 195

1. **Basic Reference:** Waterhouse, J. C. and M. P. Farrell. 1985. "Identifying Pollution and Related Changes in Chironomid Communities as a Function of Taxonomic Rank", Canadian Journal of Fisheries and Aquatic Science, 42:406-443.
2. **Procedure Objectives:** Comparison of specific and generic level analysis of chironomid preference/absence data along with heavy metal gradient.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Changes in chironomid community as a function of taxonomic rank are investigated.
5. **Level of Education Needed to Perform Procedure:** Knowledge of chironomid identification.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 196

1. **Basic Reference:** Weber, C. I. and B. H. McFarland. 1981. "Effects of Exposure Time, Season, Substrate Type and Planktonic Populations on the Taxonomic Composition of Algal Periphyton on Artificial Substrates in the Ohio and Little Miami Rivers", in *Ecological Assessments of Effluent Impacts on Communities of Indigenous Aquatic Organisms,* ASTM STP 730, J. M. Bates and C. I. Weber, Eds., American Society for Testing and Materials, pp.166-219.
2. **Procedure Objectives:** Observe effects of exposure time season, substrate type and planktonic populations on composition of periphyton communities.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Succession not observed but seasonal changes were observed in periphyton communities. Expose time necessary ranged from 1 to 4 weeks.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
x Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 197

1. **Basic Reference:** Weber, C. I. 1980. "Federal and State Biomonitoring Programs", in *Biological Monitoring for Environmental Effects*, D. Wort, Ed., Lexington Books, Lexington, MA., pp. 25-52.
2. **Procedure Objectives:** Review of state and federal biomonitoring programs.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Overview of federal and state biomonitoring programs.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 198

1. **Basic Reference:** Wefring, D. R. and J. C. Teed. 1980. "Device for Collecting Replicate Artificial Substrate Samples of Benthic Invertebrates in Large Rivers", Prog. Fish Cult., 42:26-28.
2. **Procedure Objectives:** Description of artificial substrate collecting device which provides replicate samples of benthic invertebrates in large rivers.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Design for a triplicate multi-plate artificial substrate was found to be an effective replicate method.
5. **Level of Education Needed to Perform Procedure:** Knowledge of both sampling and identification of benthic macroinvertebrates.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 199

1. **Basic Reference:** Weitzel, R. L. and J. M. Bates. 1981. "Assessment of Effluent Impacts Through Evaluation of Periphyton Diatom Community Structure", in *Ecological Assessment of Effluent Impacts on Communities of Indigenous Aquatic Organisms*, ASTM STP 730, American Society for Testing and Materials, pp.142-165.
2. **Procedure Objectives:** Determination of species richness and diversity of diatom communities collected with artificial substrates to determine the impact of electroplating waste discharge.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Periphyton was able to show changes due to waste discharge. 1000 diatom counts most cost effective.
5. **Level of Education Needed to Perform Procedure:** Knowledge of diatom collection and identification.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** One to two hours per sample (one person)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
x	Periphyton		Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 200

1. **Basic Reference:** Weitzel, R. L. 1979. "Periphyton Measurements and Applications", in *Methods and Measurement of Periphyton Communities: A Review*, ASTM STP 690, R. L. Weitzel, Ed., American Society for Testing and Materials, pp. 3-33.
2. **Procedure Objectives:** Measurement of species diversity, species abundance, biomass, biovolume and phytopigments of periphyton communities to be used as an indicator of water quality.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** A useful way to determine environmental effect. Need understanding of periphyton communities to interpret results.
5. **Level of Education Needed to Perform Procedure:** Knowledge of periphyton collection and identification.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** One to two hours per sample (one person)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

	Habitat Assessment		Population and Community Interaction
	Population Structure		Data Analysis
x	Community Structure	x	Interpretive Assessment

Community Group

	Macrophytes		Zooplankton		Other Vertebrates
x	Periphyton		Macroinvertebrates		
	Phytoplankton		Fish		

Reference Number – 201

1. **Basic Reference:** Welch, E. B. 1989. "Alternative Criteria for Defining Lake Quality for Recreation", in *Enhancing States' Lake Management Programs*, North American Lake Management Society, Washington, D. C., Proceedings of National Conference, Chicago, IL, May 12-13, pp. 7-15.
2. **Procedure Objectives:** Evaluates eutrophication indicators from the viewpoint of recreation, water supply and fish.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** This approach uses asthetics to measure eutrophication which takes into account public opinion, but this is not always the best approach for lake biology.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 202

1. **Basic Reference:** Weller, M. W. 1988. "Issues and Approaches in Assessing cumulative Impacts on Waterbird Habitat in Wetlands", Environmental Management, 12:695-701.
2. **Procedure Objectives:** Description of several approaches for estimating bird habitat losses in wetlands.
3. **Suitability for the Four Major Habitat Types**

Freshwater	Marine	Estuarine	x Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Use of vertebrates mainly birds to assess changes in wetlands.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
x Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 203

1. Basic Reference: Wetzel, R. G. 1975. "Limnology", W. B. Saunders Company, Philadelphia, PA., 743 pp.

2. Procedure Objectives: General textbook on limnology.

3. Suitability for the Four Major Habitat Types

x Freshwater	Marine	Estuarine	Wetlands

4. Primary Advantages and Disadvantages of the Procedure: Overview of limnological procedures.

5. Level of Education Needed to Perform Procedure: NA

6. Field Team Size: NA

7. Collection Time Required: NA

8. Sample Processing Time: NA

9. Data Analysis Time: NA

Subsection

Habitat Assessment	x Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	x Zooplankton	Other Vertebrates
x Periphyton	x Macroinvertebrates	
x Phytoplankton	x Fish	

Reference Number – 204

1. Basic Reference: Wiederholm, T. 1980. "Use of Benthos in Lake Monitoring", Journal of Water Pollution Control Federation, 52:537-547.

2. Procedure Objectives: Demonstrate usefulness of benthos in lake monitoring.

3. Suitability for the Four Major Habitat Types

x Freshwater	Marine	Estuarine	Wetlands

4. Primary Advantages and Disadvantages of the Procedure: Benthic macroinvertebrates incorporate both autotrophic and heterotrophic lake processes.

5. Level of Education Needed to Perform Procedure: Knowledge of sampling and identification of benthic macroinvertebrates in lakes.

6. Field Team Size: Two

7. Collection Time Required: 10 - 20 minutes per sample (two persons)

8. Sample Processing Time: 30 - 60 minutes per sample (two persons)

9. Data Analysis Time: One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 205

1. **Basic Reference:** Winner, R. M., M. W. Boesel and M. P. Farrell. 1980. "Insect Community Structure as an Index of Heavy Metal Pollution in Lotic Ecosystems", Canadian Journal of Fisheries and Aquatic Science, 37:647-655.
2. **Procedure Objectives:** Use of aquatic macroinvertebrates as an index of heavy metal pollution.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Percent composition of chironomids found as a good index of heavy metal pollution.
5. **Level of Education Needed to Perform Procedure:** Knowledge of sampling and identification of aquatic macroinvertebrates in lotic systems.
6. **Field Team Size:** One or two
7. **Collection Time Required:** 10 - 20 minutes per sample (two persons)
8. **Sample Processing Time:** 30 - 60 minutes per sample (two persons)
9. **Data Analysis Time:** One to two hours (one person)

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
x Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 206

1. **Basic Reference:** Winter, J. D. 1983. "Underwater Biotelemetry", in *Fisheries Techniques*, L. A. Nielsen and D. Johnson, Eds., American Fisheries Society, Bethesda, Maryland, pp. 371-396.
2. **Procedure Objectives:** Description of telemetry systems, methods of attaching transmitters, methods of tracking free-ranging aquatic animals and data collection and processing.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Biotelemetry can collect information on fish movements. Can be costly to invest in needed equipment. Special training necessary.
5. **Level of Education Needed to Perform Procedure:** Knowledge of fish behavior and biotelemetry techniques.
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	x Fish	

Reference Number – 207

1. **Basic Reference:** Wlosinski, J. H., and M. S. Dortch. 1985. "Development and Evaluation of a Model (ce-qual-Ri) of Reservoir Water Quality", in *Lake and Reservoir Management - Practical Applications*, North American Lake Management Society, Washington, D. C., pp. 186-194.
2. **Procedure Objectives:** Describes development of ce-qual-Ri reservoir water quality model.
3. **Suitability for the Four Major Habitat Types**

x Freshwater	Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Models allow for manipulation of parameters to test different scenarios, but these are not "real world" situations.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

x Habitat Assessment	Population and Community Interaction
Population Structure	x Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 208

1. **Basic Reference:** Wright, D. A., J. A. Mihursky, and H. L. Phelps. 1985. "Trace Elements in Chesapeake Bay Oysters: Intra-Sample Variability and Its Implications for Biomonitoring", Mar. Environ. Res., 16(3):181-197.
2. **Procedure Objectives:** Determination of intra-sample variability to determine optimum sample size of bay oysters.
3. **Suitability for the Four Major Habitat Types**

Freshwater	x Marine	Estuarine	Wetlands

4. **Primary Advantages and Disadvantages of the Procedure:** Use of a single indicator organisms simplifies biomonitoring. This method is specific to certain pollutants and not a broad range of environmental impacts.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	x Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 209

1. **Basic Reference:** Wrona, F. J., J. M. Culp and R. W. Davies. 1982. "Macroinvertebrate Subsampling: A Simplified Apparatus and Approach", Can. J. Fish. Aquatic Sci., 39:1051-1054.
2. **Procedure Objectives:** Protocols for the use of a volumetric subsampling apparatus for processing macroinvertebrates.
3. **Suitability for the Four Major Habitat Types**

   x Freshwater x Marine x Estuarine x Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Subsampling apparatus is advantages in reducing the amount of sample (randomly) to reduce processing time.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
Population Structure	Data Analysis
Community Structure	x Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	x Macroinvertebrates	
Phytoplankton	Fish	

Reference Number – 210

1. **Basic Reference:** Zhirmunsky, A. V. and N. K. Khristoforova. 1986. "Some Methods of Biological Assessment of Marine Environment Pollution", in *Integrated Global Ocean Monitoring*, Proceedings of the 1st International Symposium, Tallin, U.S.S.R., pp. 110-116.
2. **Procedure Objectives:** Determine useful indicator organisms to monitor pollution levels. Describe cellular and molecular responses.
3. **Suitability for the Four Major Habitat Types**

   Freshwater x Marine Estuarine Wetlands
4. **Primary Advantages and Disadvantages of the Procedure:** Aquatic organisms may be used as indicator organisms to assess heavy metal pollution in marine systems.
5. **Level of Education Needed to Perform Procedure:** NA
6. **Field Team Size:** NA
7. **Collection Time Required:** NA
8. **Sample Processing Time:** NA
9. **Data Analysis Time:** NA

Subsection

Habitat Assessment	Population and Community Interaction
x Population Structure	Data Analysis
Community Structure	Interpretive Assessment

Community Group

Macrophytes	Zooplankton	Other Vertebrates
Periphyton	Macroinvertebrates	
Phytoplankton	Fish	

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